EXHIBIT F

Invalidity Claim Chart For
The '195 Patent

USP 5,572,195	USP 5,150,310 (GREENSPUN)	USP 5,402,469 (HOPPER)	USP 5,426,425 (CONRAD)	USP 5,455,851 (CHACO)
CLM 1. An object location and tracking system for tracking infrared transmitters that transmit identifying codes, comprising:	Abstract; Col. 1, ln. 6-11; Col. 5, 1-15, 20-21, 26-31	Abstract; Col. 2, ln 54-56	Abstract; Col. 2, ln 40-53; Col. 3, ln 27-55; Col. 5, ln 25-28; Col. 8, ln 25-Col. 9,ln 8	Abstract; Col. 2, ln 5-19
a computer network for passing messages;	Col. 8, ln. 5-12	Col. 4, ln 50-53	Col. 4, ln 60-Col. 5, ln 4; Col. 11, ln 1-15; Col. 13, ln 1-35	Col. 2, ln 39-45; Col. 3, ln 48-Col. 4, ln 27
a computer connected to said network, said computer including means for sending and receiving messages over said computer network in a variable-based protocol that implements object identifier variables;	Col. 5, ln. 10-15, 50-55; Col. 6, ln. 40-54; Col. 8, ln. 36-54 Col. 5, ln. 32-40; Col. 7, ln 3-7, 33-48 Col. 8, line 5-12; Col 10, ln 30-39	Col. 2, ln 51-Col. 3, ln 8; Col. 5, ln 19-Col 6, ln 32	Col. 5, ln 5- Col. 6, ln 41;	Col. 2, ln 26-30; Col. 3, ln 3-Col. 4, ln 26
a plurality of infrared sensors for receiving transmitted identifying codes from the infrared transmitters, said plurality of infrared sensors providing signals containing the transmitted identifying codes; and	Col. 5, ln. 6-10, 32-55; Col. 6, ln. 40-47; Col. 8, ln. 59-66	Col. 2, ln 51-Col. 3, ln 8; Col. 4, ln 65-Col 5, ln 4	Col 2, ln 54-62; Col. 5, ln 25-35; Col. 9, ln 10-Col. 10, ln 65	Col. 2, ln 22-29; Col. 3, ln 13-Col. 4, ln 26 Col. 7, ln 61-Col. 8, ln 10

interface circuitry coupling said plurality of infrared sensors to said computer network, said interface circuitry including means for providing to said computer network object identifier variables in the variable-based protocol corresponding to the transmitted identifying codes received from said signals from said plurality of infrared sensors.	Col. 7, ln 3-10; Col. 10, lns 30-54	Col. 2, ln 51-Col 3, ln 8; Col. 5, ln 11-Col. 6, ln 24	Col. 5, ln 5- Col. 6, ln 41; Col. 11, ln 18-Col. 12, ln 50	Col. 3, ln 13-Col. 4, ln 26; Col. 8, ln 10-17; Col. 8, ln 54-Col. 9, ln 36

CLM 13. A method for tracking and locating objects in a system with a computer network, a computer connected to the computer network, infrared sensors, and interface circuitry connecting the computer network to the infrared sensors, the infrared sensors being adapted to receive unique identifying codes from infrared transmitters, comprising the steps of:	Abstract; Col. 1, ln. 6-11; Col. 5, 1-15, 20-21, 26-31; Col. 8, ln. 5-12; Col. 5, ln. 10-15, 50-55; Col. 6, ln. 40-54; Col. 8, ln. 36-54; Col. 5, ln. 32-40; Col. 7, ln 3-7, 33-48; Col. 8, line 5-12; Col 10, ln 30-39; Col. 5, ln. 6-10, 32-55; Col. 6, ln. 40-44; Col. 8, ln. 59-66 Col. 7, ln 3-10	Abstract; Col. 2, ln 54-56 Col. 4, ln 50-53; Col. 4; ln 55; Col. 5, ln 19-Col 6, ln 30; Col. 4, ln 65-Col 5, ln4; Col. 2, ln 65-70; Col 5, ln 6-19	Abstract; Col. 2, ln 40-53; Col. 3, ln 27-55; Col. 5, ln 25-28; Col. 8, ln 25-Col. 9,ln 8; Col. 4, ln 60-Col. 5, ln4; Col. 11, ln 1-15; Col. 13, ln 1-35; Col. 3, ln 7-9; Col. 4, ln 55-60; Col 2, ln 55-62; Col. 5, ln 28-34; Col 9, ln 10-Col. 10, ln 65; Col. 5, ln 5-24; Col. 11, ln 18-Col. 12, ln 50	Abstract; Col. 2, ln 5-19; Col. 2, ln 39-45; Col. 3, ln 48-Col. 4, ln 27; Col. 2, ln 26-30; Col. 3, ln 29-47; Col. 2, ln 22-26; Col. 7, ln 61-Col. 8, ln 10; Col. 8, ln 10-17; Col. 8, ln 54-Col. 9, ln 36

providing object identifier variables in the interface circuitry, said object identifier variables adapted for being communicated over the computer network in a variable based protocol;	Col. 8, ln 27-35; Col. 7, lns 33-48; Col. 10, lns 30-39	Col. 2, ln 51-Col. 3, ln 8	Col. 3, ln 7-9; Col. 4, ln 55-60; Col. 5, ln 5-Col. 6, ln 41	Col. 3, ln 13-Col. 4, ln 26; Col. 8, ln 54-Col. 9, ln 16
receiving in one of the infrared sensors a transmission from one of the infrared transmitters containing a unique identifying code;	Col. 7, ln 3-Col. 8, ln 8	Col. 2, ln 51-Col. 3, ln 8; Col. 4, ln 65-Col. 5, ln 4	Col. 2, ln 54-62; Col. 5, ln 25-35; Col. 9, ln 10-Col. 10, ln 65	Col. 2, ln 22-29; Col. 3, ln 13-Col. 4, ln 26; Col. 8, ln 19-52
sending the received unique identifying code from the infrared sensor to the interface circuitry;	Col. 7, ln 3-Col. 8, ln 8	Col. 2, ln 51-Col. 3, ln 8; Col. 5, ln 14-18	Col. 5, ln 5-24	Col. 3, ln 13-Col. 4, ln 26; Col. 8, ln 10-17
providing the unique identifying code in the interface circuitry to the computer network in association with an object identifier variable; and	Col. 8, ln 9-12	Col. 2, ln 51-Col. 3, ln 8; Col. 5, ln 11-Col. 6, ln 24	Col. 5 ln 5-24; Col. 11, ln 18-Col. 12, ln 50	Col. 3, ln 13-Col. 4, ln 26; Col. 8, ln 10-17; Col. 8, ln 54-Col. 9, ln 16
receiving in the computer the unique identifying code from the network by accessing its associated object identifier variable.	Col. 8, ln 9-35	Col. 2, ln 51-Col. 3, ln 8; Col. 5, ln 11-Col. 6, ln 24	Col. 5, ln 35-45	Col. 3, ln 13-Col. 4, ln 26; Col. 9, ln 16-36

Invalidity Claim Chart for
The '791 Patent

USP RE 36,791	USP 4,611,198 (LEVINSON)	USP 5,319,363 (Welch)
Clm 25. A location system for locating objects within a tracking environment using area-detection by receivers that receive electromagnetic transmissions *from assigned areas*, comprising:	Abstract; Col. 1, ln. 24 – Col. 2, ln. 30.	Col. 2, ln. 58 - Col 3, ln. 14.
for each object, a TAG transmitter for transmitting, at selected intervals, TAG transmissions that include a unique TAG ID;	Col. 1, ln 24-29; Col. 2, ln 7-8; Col. 3, ln. 21-22; Col. 4 ln. 26-35	Col. 2, ln. 58-67; Col. 7, ln. 51-52; Col. 8, ln. 41-46;
an array of receivers distributed within the tracking area, with each receiver being configured to receive TAG transmissions from *an assigned area of a predetermined size*;	Col. 1, ln. 40-63; Col. 4, ln. 35-46;	Col. 2, ln. 60-64; Col. 8, ln. 34-40

each receiver including a data communications controller responsive to the receipt of a TAG transmission for providing a corresponding area-detection packet that includes the received TAG ID; and	Col. 4, ln. 52-64	Col. 2, ln. 65-67; Col 8, ln. 46-49
a location processor for receiving the area-detection packets, and for determining the location of each TAG, and its associated object, *based on the identity of the receiver receiving the TAG transmissions for that TAG.*	Col. 5, ln. 1-11	Col. 2, ln. 68-Col. 3, ln. 32; Col. 6, ln 47-Col. 7, ln. 57; Col. 8, ln. 46-55

Clm 48. A method of locating objects within a tracking environment using area-detection by receivers that receive electromagnetic transmissions *from assigned areas*, comprising:	Abstract; col. 1, ln. 24 – col. 2, ln. 30.	Col. 2, ln. 58-Col 3, ln. 14.
for each object, providing a TAG transmitter for transmitting, at selected intervals, TAG transmissions that include a unique TAG ID;	Col. 1, ln 24-29; Col. 2, ln 7-8; Col. 3, ln. 21-22; Col. 4 ln. 26-35	Col. 2, ln. 58-67; Col. 7, ln. 51-52; Col. 8, ln. 41-46;
providing an array of receivers distributed within the tracking area, with each receiver being configured to receive TAG transmissions *from an assigned area of a predetermined size*;	Col. 1, ln. 40-63; Col. 4, ln. 35-46;	Col. 2, ln. 60-64; Col. 8, ln. 34-40

each receiver being responsive to the receipt of a TAG transmission for providing a corresponding area-detection packet that includes the received TAG ID; and	Col. 4, ln. 52-64	Col. 2, ln. 65-67; Col 8, ln. 46-49
determining the location of each TAG, and its associated object, *based on the identity of the receiver* receiving the TAG transmissions for that TAG as represented by the area-detection packet provided by such receiver that received the TAG transmissions.	Col. 5, ln. 1-11	Col. 2, ln. 68-Col. 3, ln. 32; Col. 6, ln 47-Col. 7, ln. 57; Col. 8, ln. 46-55

Clm 66. A location system for locating objects within a tracking environment using area-detection by receivers that receive transmissions from assigned areas, comprising:	Abstract; col. 1, ln. 24 – col. 2, ln. 30.	Col. 2, ln. 58-Col 3, ln. 14.
for each object, a TAG transmitter for transmitting at selected intervals, TAG transmissions that include a unique TAG ID;	Col. 1, ln 24-29; Col. 2, ln 7-8; Col. 3, ln. 21-22; Col. 4 ln. 26-35	Col. 2, ln. 58-67; Col. 7, ln. 51-52; Col. 8, ln. 41-46;
an array of receivers distributed within the tracking area, with each receiver being configured to receive TAG transmissions from an assigned area of a predetermined size;	Col. 1, ln. 40-63; Col. 4, ln. 35-46;	Col. 2, ln. 60-64; Col. 8, ln. 34-40

each receiver including a data communications controller responsive to the receipt of a TAG transmission for providing a corresponding area-detection packet that includes the received TAG ID;	Col. 4, ln. 52-64	Col. 2, ln. 65-67; Col 8, ln. 46-49
a location processor for receiving the area-detection packets, and for determining the location of each TAG, and its associated object, based on the identity of the receiver receiving the TAG transmissions for that TAG; and	Col. 5, ln. 1-11	Col. 2, ln. 68-Col. 3, ln. 32; Col. 6, ln 47-Col. 7, ln. 57; Col. 8, ln. 46-55

a local area network, said array of receivers being coupled to the location processor by said local area network, with each receiver including a LAN interface, such that the area detection packets are communicated to the location processor over said LAN.		Col. 3, ln 9-12; Col. 7, ln 44-56; Col. 8, ln 46-55

US005455851A

United States Patent [19]

[11] **Patent Number: 5,455,851**

[45] **Date of Patent: Oct. 3, 1995**

Chaco et al.

[54] **SYSTEM FOR IDENTIFYING OBJECT LOCATIONS**

[75] Inventors: **John Chaco**, Seymour; **Yaron Ram**, Stamford, both of Conn.

[73] Assignee: **Executone Information Systems, Inc.**, Milford, Conn.

[21] Appl. No.: **87,394**

[22] Filed: **Jul. 2, 1993**

[51] **Int. Cl.**⁶ **H04M 11/04**; G08B 5/22

[52] **U.S. Cl.** **379/38**; 379/37; 340/825.49

[58] **Field of Search** 379/37, 38, 57, 379/58, 93, 201; 340/539, 573, 825.49, 825.54, 825.55, 543; 455/56.1, 33.3; 367/117, 119; 359/143, 142, 154, 157; 342/450; 235/380, 381, 382; 40/1.5

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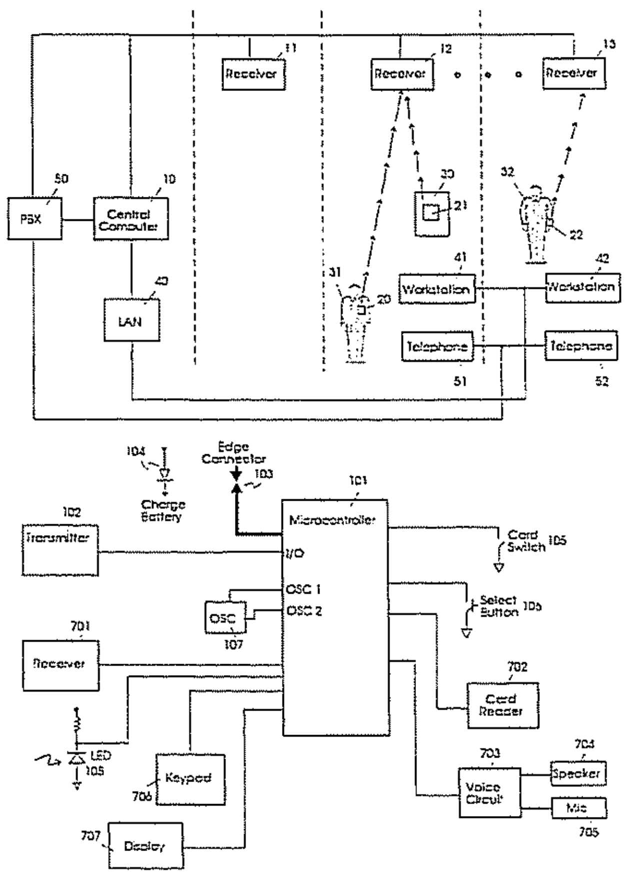
2630565	10/1989	France .
2225141	5/1990	United Kingdom .
93/09621	5/1993	WIPO .

Primary Examiner—Curtis Kuntz
Assistant Examiner—Jason Chan
Attorney, Agent, or Firm—Dilworth & Barrese

[57] **ABSTRACT**

An objection location system for locating and communicating with personnel or objects within a facility. Remote badges are coupled to respective objects or personnel to be located. The badges include transmission means for transmitting identification information associated with their respective objects or personnel. Operational parameters are stored in the badges and are monitored for controlling the operation of the badges. The badge may be in the form of a wristband.

41 Claims, 7 Drawing Sheets



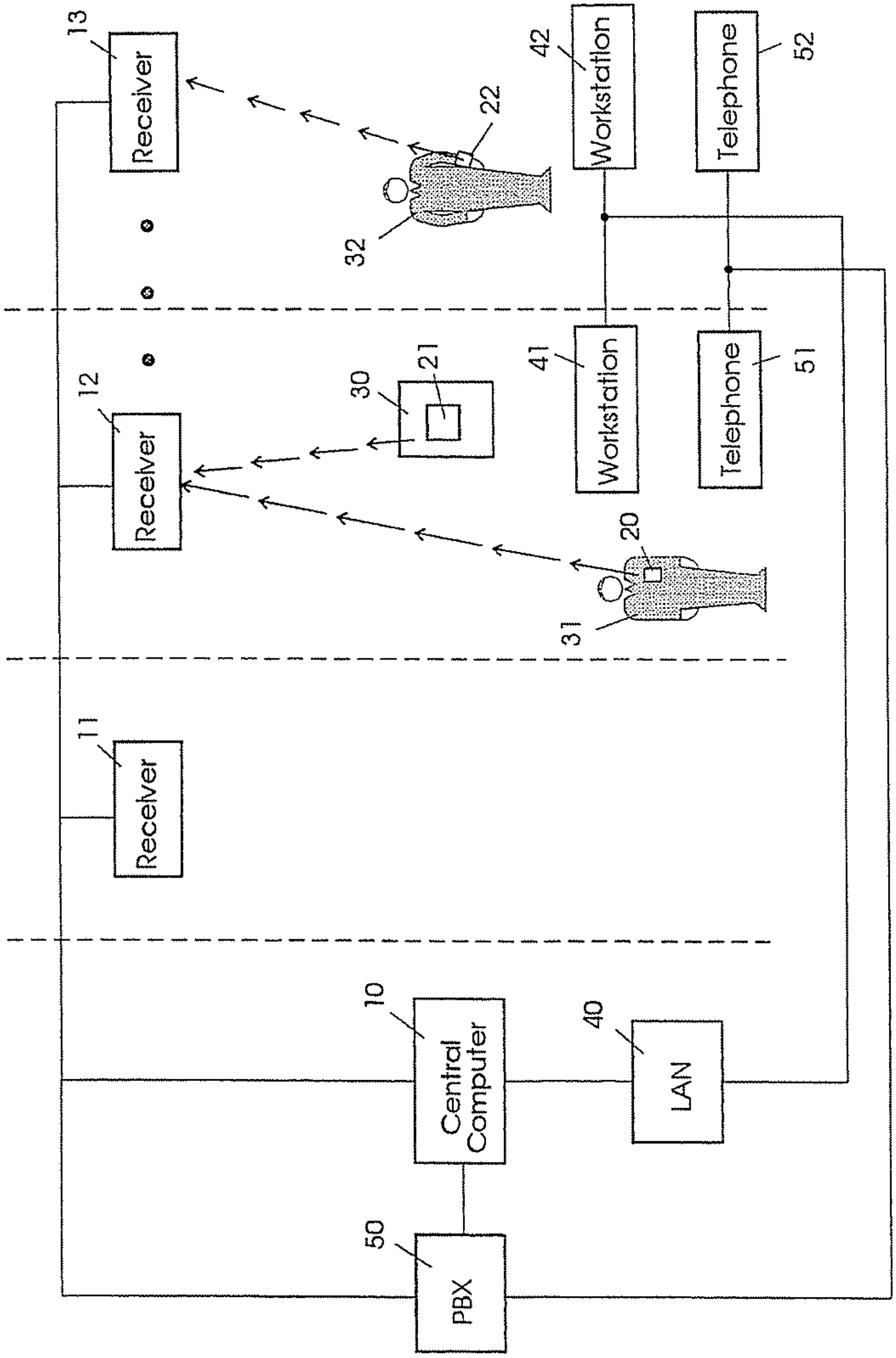

Receiver
13
22
32
Workstation
42
Telephone
52
Receiver
12
30
21
41
Workstation
Telephone
51
20
31
Receiver
11
Central Computer
10
LAN
40
PBX
50

Figure 1

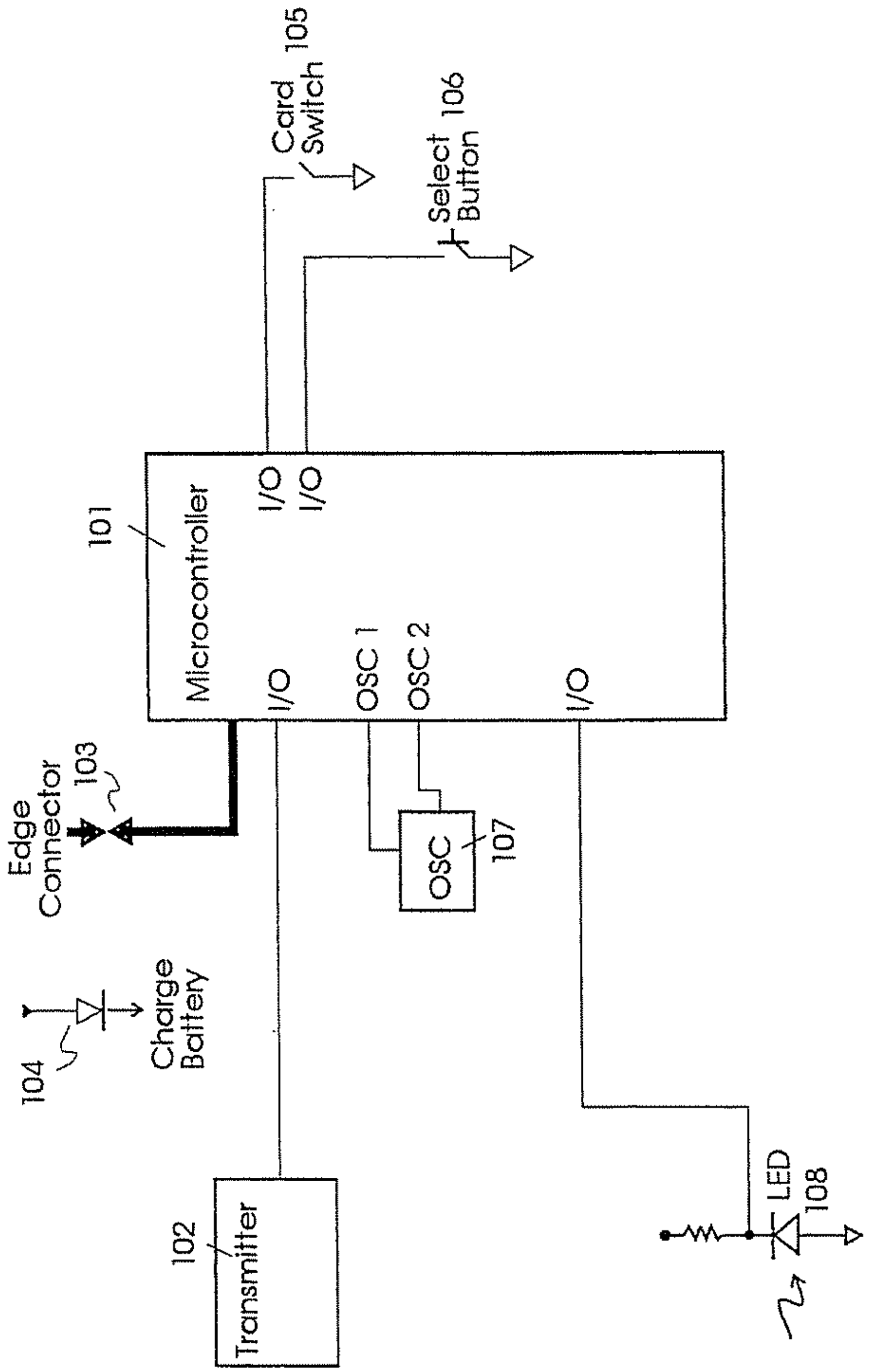
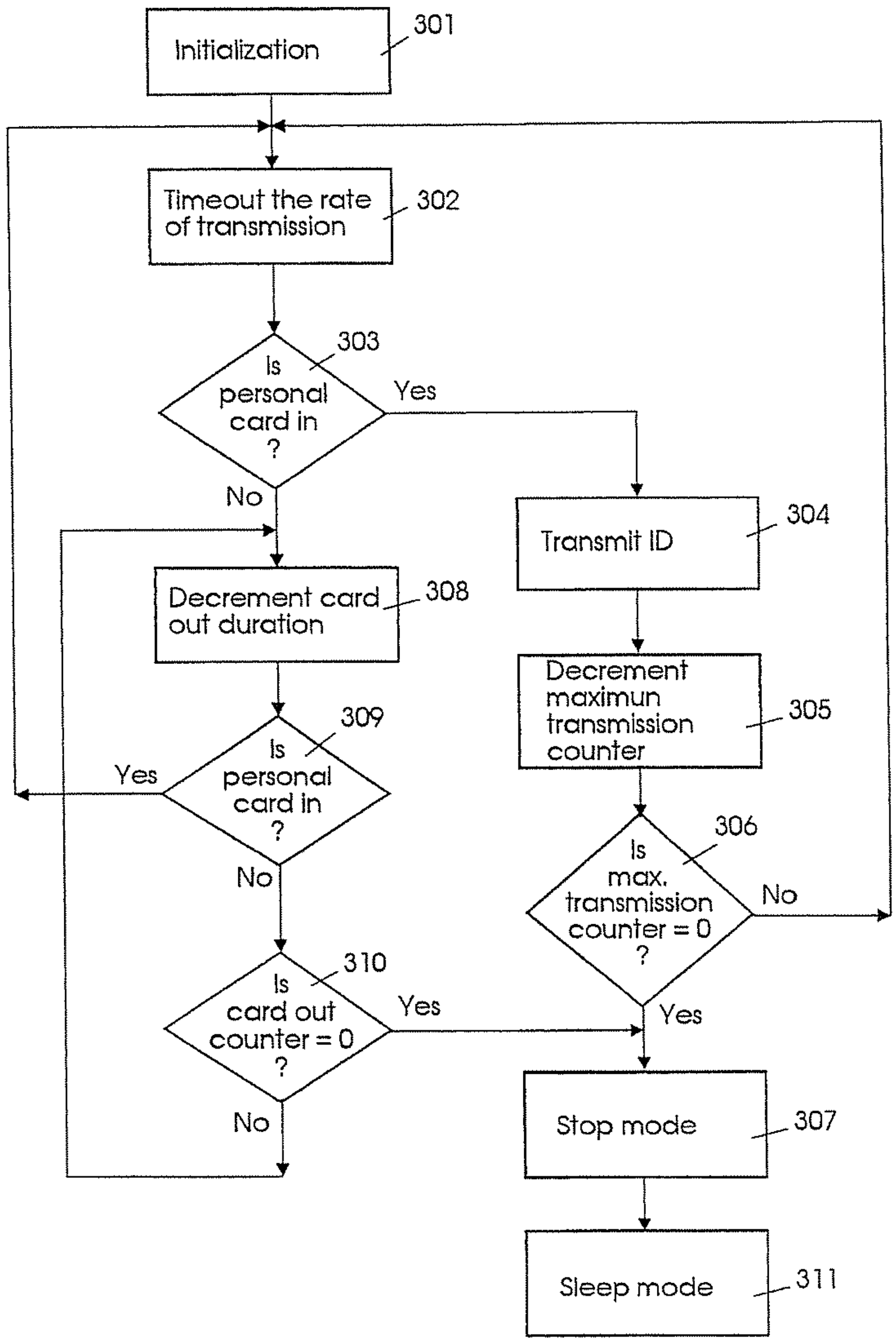

Card Switch
105
Select Button
106
101
Microcontroller
I/O
I/O
I/O
OSC 1
OSC 2
I/O
Edge Connector
103
OSC
107
104
Charge Battery
102
Transmitter
LED
108

Figure 2



Initialization
301
Timeout the rate of transmission
302
Is personal card in ?
303
Yes
No
Transmit ID
304
Decrement card out duration
308
Decrement maximun transmission counter
305
Is personal card in ?
309
Yes
No
Is max. transmission counter = 0 ?
306
No
Yes
Is card out counter = 0 ?
310
Yes
No
Stop mode
307
Sleep mode
311

FIGURE 3

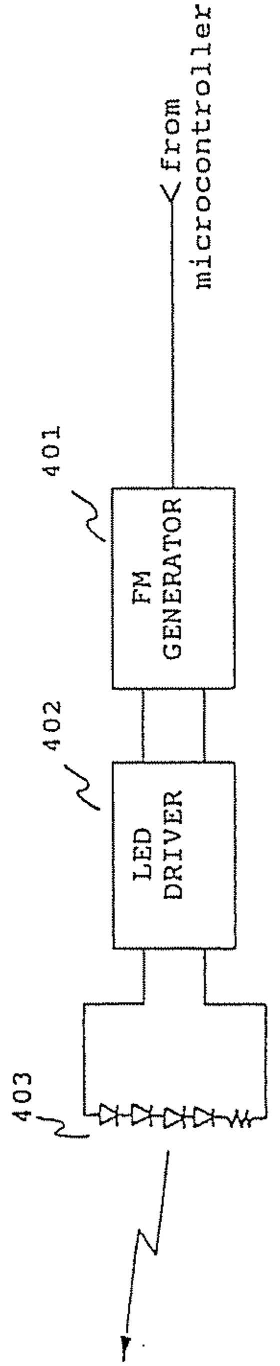

from
microcontroller
401
FM
GENERATOR
402
LED
DRIVER
403

FIG. 4

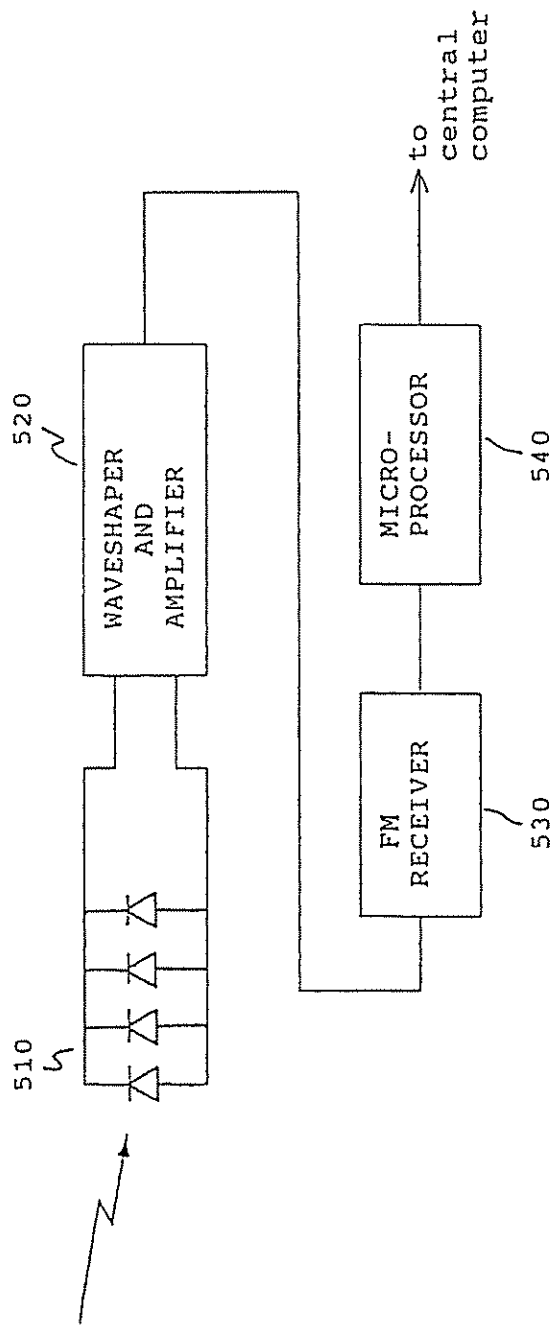

to
central
computer
520
WAVESHAPER
AND
AMPLIFIER
MICRO-
PROCESSOR
540
FM
RECEIVER
530
510

FIG. 5

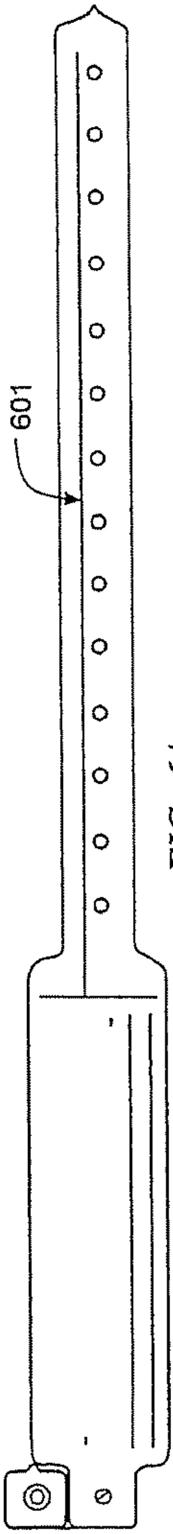


FIG. 6A

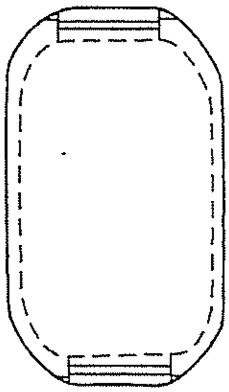


FIG. 6B

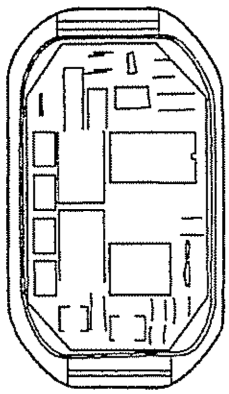


FIG. 6C

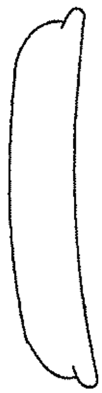
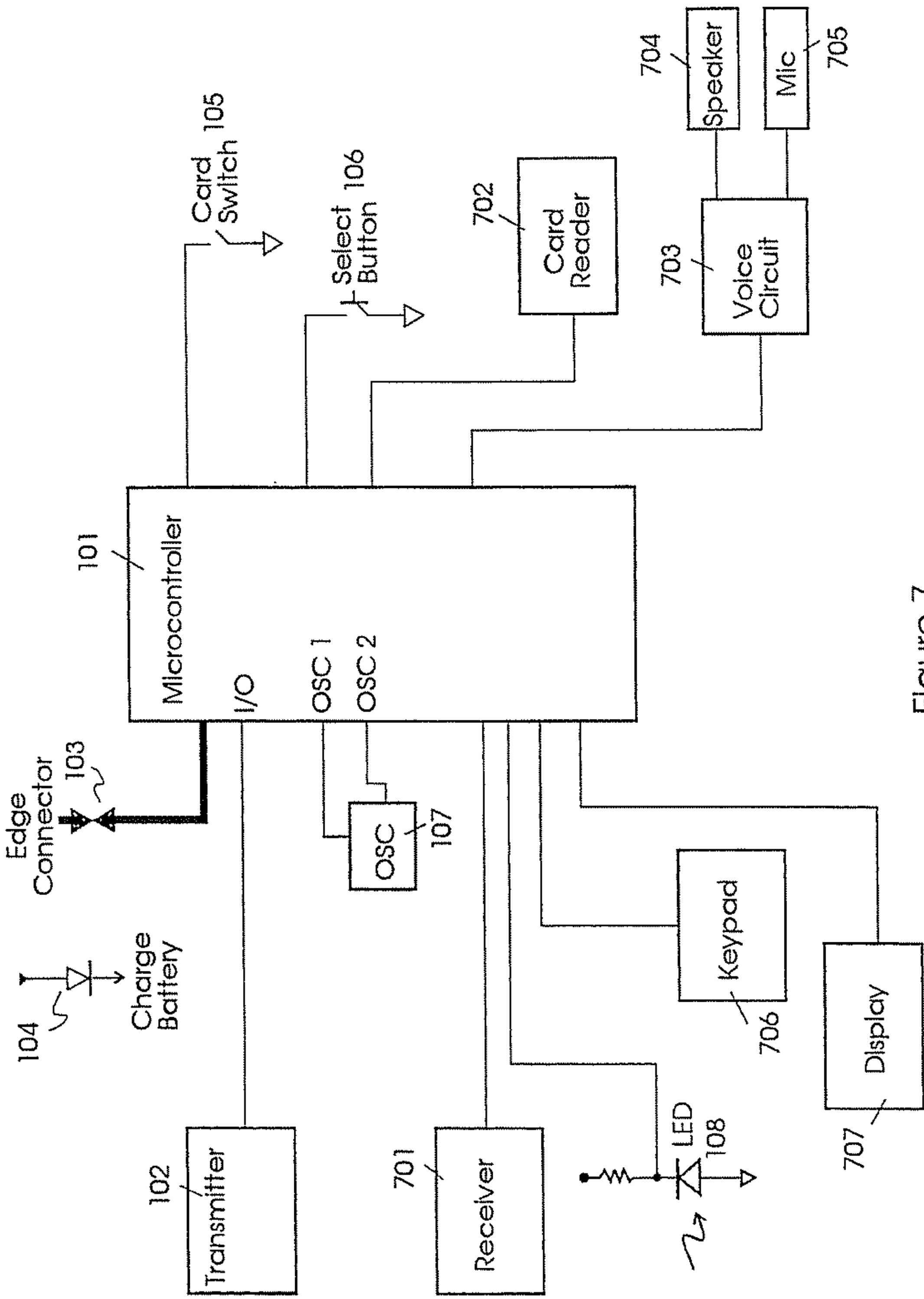


FIG. 6D



Card Switch
105
Select Button
106
702
Card Reader
704
Speaker
705
Mic
703
Voice Circuit
101
Microcontroller
I/O
OSC 1
OSC 2
Edge Connector
103
OSC
107
104
Charge Battery
Keypad
706
Display
707
102
Transmitter
701
Receiver
LED
108

Figure 7

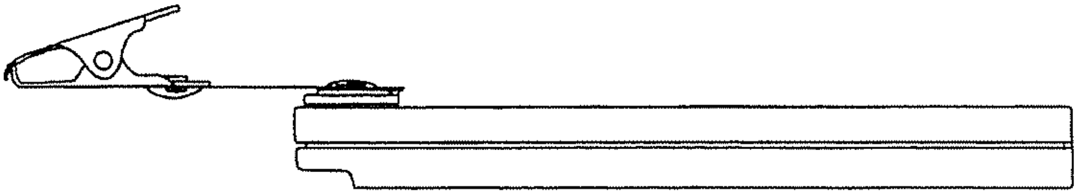


FIG. 8A

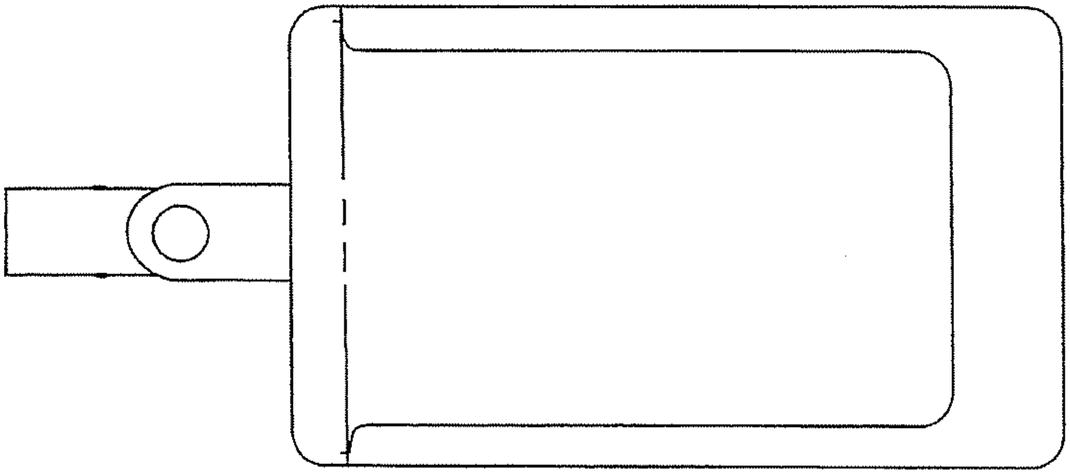


FIG. 8B

SYSTEM FOR IDENTIFYING OBJECT LOCATIONS

TECHNICAL FIELD OF THE INVENTION

This invention relates to an object location system, more particularly a system having a compact and intelligent badge or bracelet attached to an object for determining the location of the object.

BACKGROUND OF THE INVENTION

Location systems for locating objects or personnel within a facility are known. One type of personnel location system used in hospitals involves personnel within the facility reporting their locations by manually setting switches at designated areas. The switches are monitored at a central station and the locations of the personnel are determined by the locations of the activated switches. Other proposed personnel or object location techniques include systems which locate personnel or objects by seeking out where the object or personnel is closest to designated monitors. Such systems generally include a central controller connected to a plurality of transceivers distributed at designated locations throughout a facility. Portable units are worn or attached to objects or personnel to be located. Each portable unit is assigned a unique identification. To locate a personnel, the central controller causes the transceivers to broadcast or page the portable unit by its identification. The broadcast or page signal is received by the portable units but only the portable unit having a matching identification will respond with a confirmation signal, which is received by the transceiver located closest to the responding portable unit. The transceiver in turn reports to the central controller that it has received a confirmation signal. The location of the portable unit is determined by the central controller by the message received from the transceiver. Location systems employing such location technique are described in U.S. Pat. No. 4,649,385 to Aires et al. and U.S. Pat. Nos. 3,805,265, 3,805,226 and 3,696,384 to Lester. One problem with the systems of this type is in the portable units. They must include electronics with adequate sensitivity to receive signals broadcast from the transceivers and adequate power to transmit a reply. The portable units became bulky and cumbersome and therefore inconvenient to be worn or attached.

U.S. Pat. No. 4,955,000 to Nastrom and U.S. Pat. No. 5,119,104 to Heller propose location reporting systems which include portable electronic units worn or attached to objects. The portable units periodically transmit individually unique ID signals. A plurality of transceivers are distributed at designated locations and the transceiver(s) within range of the portable unit transmissions receives the transmitted ID signals. The transceiver(s) in turn communicates the ID information to the central control unit. From the location of the transceiver and the ID of the portable unit, the central control unit is able to determine the location of the object. A disadvantage of this type of location system is the large amount of energy required to periodically transmit information from a portable unit, causing a continual drain on the power source. A large battery is required for usage of the portable unit for any meaningful period of time. The size of the portable unit is then dictated by the size of the battery. Further, unless the portable unit is efficiently used, frequent battery replacement and maintenance is required.

It can be seen that there exists a need for a location system

having portable units which are compact in size and include capability to optimize the efficiency of operation.

SUMMARY OF THE INVENTION

The present invention is an object location system for locating and communicating with personnel or objects within a facility. The system according to the preferred embodiment of the present invention comprises a plurality of badges coupled to objects, each of the badges including: wireless transmitters for transmitting signals including a unique identification signal; a processor having associated memory and stored programs, the memory having a database with stored information including a plurality of operational parameters. The stored programs are executed by the badge processor for controlling badge operations including the control of the wireless transmitter depending upon the processing of the operational parameters. The badge is also capable of interfacing with an external device for data entry including the operational parameters into the badge memory. The location system of the present invention also includes a plurality of receivers disposed at spaced apart areas within the facility, each of the receivers is capable of receiving signals including the ID signals transmitted from the wireless transmitters of the badges, and a processor for processing the received information. A central processor receives messages from the plurality of receivers and the messages are periodically processed by the central processor for determining the location of each of the badges.

In another embodiment, the electronics of the badge unit is integrated in a housing which is attached to a bracelet which can be worn by a person, such as his wrist or ankle.

In a further embodiment of the present invention, the badge unit further includes an infrared receiver, a voice circuit with associated speaker and microphone for facilitating voice communication, a keypad for data entry, and a display for displaying information.

In still another embodiment of the present invention, the receivers are coupled to a PBX, which is coupled to the central computer and a plurality of telephones throughout the facility. The badge identification information is reported to the PBX and/or the central computer, facilitating the retrieval of location information of any identified personnel from any telephone connected to the PBX.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates the components of the location system according to the present invention.

FIG. 2 is a block diagram of the components of the basic badge unit according to the present invention.

FIG. 3 is a flow diagram of the operation of the basic badge unit according to the present invention.

FIG. 4 is a block diagram of the components of the badge unit transmitter according to the present invention.

FIG. 5 is a block diagram of the components of the receiver unit according to the present invention.

FIG. 6A illustrates the bracelet embodiment according to the present invention;

FIG. 6B illustrates the top view of the housing for attachment to the bracelet;

FIG. 6C illustrates the top view of the housing when the housing is opened;

FIG. 6D illustrates the side view of the housing of the bracelet.

FIG. 7 illustrates a block diagram of an alternate embodiment of the badge unit according to the present invention.

FIG. 8A illustrates the side view of the housing of the badge unit according to the present invention.

FIG. 8B illustrates the top view of the housing of the badge unit according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates an exemplary use of the badge and bracelet units in a location and communication system ("locator system") in accordance to the present invention. A plurality of receivers **11**, **12** and **13** are disposed spatially apart throughout a facility such as an office or a hospital. Each receiver receives signals transmitted by the badges and bracelets which are within the receiver's range of reception. Each receiver is identifiable by central computer **10**. Badge **20** and bracelet **22** are worn by facility personnel **31**, **32** and badge **21** is shown attached to object **30**, which may be a facility equipment which may be mobile, commonly used, but in short supply. Each of the badges and bracelets transmits signals including an individually unique identification at selected intervals. The signals are received by the most proximal receiver and the receiver in turn communicates the received information to the central computer **10**. The central computer **10** includes in its memory the storage of information pertaining to the physical aspects of the facility such as rooms, floors, the identification of each receiver and its associated location, the identification of each badge or bracelet in operation and information regarding the object or person associated with each badge or bracelet. The central computer **10** receives messages from each receiver at selected intervals. Included in the messages are information last received by each of the receivers. The central computer **10** processes the messages received from the receivers and substantially continually updates the location of each badge or bracelet and its associated person or object within the facility. Location identification information may be retrieved from the central computer **10** by inquiring by badge identification, personnel name, and/or receiver identification. The central computer **10** may respond with the most recently updated information or respond with a history of location information from its memory. For example, a report on who visited a room, when and for how long.

The central computer **10** further communicates with LAN (local area network) **40**, which in turn may be connected to a plurality of personal computers or workstations **41** and **42**, facilitating communication with the central computer **10** and retrieval of updated location information from stations connected to the LAN **40** throughout the facility. According to the preferred embodiment, the central computer **10** may be an IBM compatible personal computer. A LAN compatible with the IBM PC protocol is coupled to the central computer **10**.

A telephone PBX (private-branch exchange) **50** couples to the plurality of receivers, the central computer **10**, and to a plurality of telephones throughout the facility, e.g., telephones **51** and **52**. The system configuration as shown facilitates direct communication of the receivers with the central computer **10** or the PBX **50**. The receivers may also communicate with the central computer **10** through the PBX **50** or communicate with the PBX **50** through the central computer **10**. The system as configured allows the flexibility of processing and transferring the information received from the receivers by the central computer **10** or shared processing and transferring responsibilities between the central computer **10** and the PBX **50**. For example, the PBX **50** may store the information such as the identity and location of each receiver. When a message is received by the PBX **50** from a receiver, the PBX adds the receiver identity or location information to the message and forwards the message to the central computer **10** for further processing and updating. Alternatively, the functions and components of the central computer **10** may be integrated within PBX **50**. In such alternate embodiment, the PBX **50** performs the functions described for both central computer **10** and PBX **50**.

Another exemplary usage of the system is the location of personnel with the telephones. For example, personnel **31** may locate personnel **32** by dialing the ID of personnel **32** on telephone **51**. The PBX receives the call from telephone **51** and inquires the central computer **10** as to the location of personnel **32**. The central computer **10** retrieves the location information of personnel **32** and identifies that he is at the location associated with receiver **13**. The central computer **10** responds to the PBX **50** with the location information. The PBX **50** in turn dials the telephone **52**, which may be equipped with a display and a speaker for announcing or displaying the name of personnel **32**. A PBX such as the IDS **228**, manufactured by Executone Information Systems, Inc., is preferred in accordance to the present invention.

FIG. 2 shows the components of the basic badge unit according to the preferred embodiment of the present invention. The bracelet embodiment according to the present invention includes substantially the same components shown in FIG. 2. Unless specifically described otherwise, the following descriptions for the basic badge unit is equally applicable to the bracelet unit. The basic badge unit includes a microcontroller **101** for controlling the operations of the badge and a transmitter **102** for transmitting signals to a plurality of receivers. The microcontroller **101** is preferably a single integrated circuit chip which includes a processor and RAM and ROM memory. The ROM memory may be of the programmable type and stores software programs for operating the badge. These programs include: program for controlling the transmitter **102**; for monitoring operational parameters; and for interfacing with external devices. The RAM memory includes a database for storing information including the identification code of the badge and operational parameters which are retrieved and monitored by the processor for operating the badge unit. The database may further include information regarding the person associated with the badge, e.g., medicine which the person is allergic to. The database may also include information relating to an associated object, e.g., medical equipment and its operating parameters or data. The processor functions include: logical and arithmetic operations and coordination of data transfer to and from the microcontroller **101**. A microcontroller such as the PIC®16C5X manufactured by Microchip Technology, Inc. is used in the preferred embodiment of the present invention. It is apparent to one skilled in the art that any microcontroller having equivalent performance characteristics and similar in size may also be used.

An edge connector **103** facilitates interfacing to the components of the badge from an external device (not shown). The edge connector **103** preferably has four connections which include a "Bidirect I/O" connection to an input/output port of the microcontroller **101** for bidirectional communication with the microcontroller **101**. Data can be written into or read out of the microcontroller memory by the external device ("the Base") through this connection. The Base

preferably includes processing, storage and interfacing capabilities for communicating with and transferring information between the Base and the badge. A standard serial interface protocol such as RS232 may be used. An "In-Base" connection is monitored by the microcontroller **101**. An active signal at the "In-Base" input indicates that the microcontroller is to relinquish control to the external device. The badge according to the present invention is powered by a battery, which preferably is made of lithium. Other battery designs such as a NICAD (nickel cadmium) rechargeable type or solar cell may also be used. Another input of the edge connector **103** may be used to recharge the battery. The fourth connection of the edge connector **103** is a spare input/output. The badge includes a light sensitive LED **108** for providing wireless means for inputting data to the microcontroller **101** by serially strobing data with a light source into the microcontroller **101**.

An oscillator **107** is connected to the microcontroller **101** for providing an oscillation signal, which in turn generates a clock signal for clocking or timing purposes. In the preferred embodiment, the oscillator **107** includes a resistor/capacitor combination for providing a clock which operates at a frequency of around 455 kilohertz. Due to variations in the tolerances of the resistor/capacitor combination, the clock rate for each badge unit will vary from one badge to another substantially around 455 kilohertz. The microcontroller **101** includes a prescaler for providing timing and clock signals.

According to the preferred embodiment of the present invention, the electronics of the badge is enclosed in a housing which is shaped and sized like an ordinary credit card. FIGS. **8A** and **8B** illustrate the side and top views, respectively, of the badge housing, which is shown attached to a clip. The housing as shown is around 3.8" in length, 2.27" in width and 0.39" in thickness. The housing includes a slot for slidingly mating with a personnel card. A card switch **105** is disposed in the slot of the housing in the path of the personnel card such that when the personnel card is inserted into the housing, the card switch **105** is opened. The personnel card may be an ordinary business card or a smart card having electronically stored information.

A select button switch **106** facilitates manual communication to the microcontroller **101** for functions such as mode select or transmission of a preselected message, dependant upon the number and sequence of button pushes. The modes of operation include: "erase memory" for erasing the contents of the RAM memory; "turn-off transmitter" for disabling any transmission from the badge; "card reinsertion" for turning off the badge when the personnel card is removed until a card is reinserted; "ID code change" for changing the ID code to a special preselected code to signal an abnormal condition; and "disable counters" mode, which overrides parameter operations for turning off or disabling the badge and maintains badge operations.

Parameter and Database Storage

The RAM memory of the microcontroller **101** includes storage of parameter values and a database for storage of information including identification information. The data can be written into and read out of the RAM memory by the base through the edge connector **103**. Data can also be serially strobed into the RAM memory via LED **108**. The parameter data in the RAM is accessed by the microcontroller processor under the control of the software programs stored in the ROM memory. The parameters are used to safeguard against unauthorized usage of the badge and to conserve battery power. The parameters include: rate of transmission; maximum duration of operation; card-out duration; maximum number of transmissions; and the length of the ID.

The "rate of transmission" parameter is the time rate or period between each transmission from the transmitter **102**. This parameter value is input to a counter and is counted down to zero until the next transmission. The actual rate of transmission will vary from badge to badge even if each badge is preset with the same rate of transmission because the microprocessor clock is derived from a resistor/capacitor time constant network and the microprocessor clock period will necessarily vary along with the variations within the tolerance of the resistor/capacitor devices. With such variations, when more than one badge is transmitting to the same receiver, the likelihood of two consecutive transmission bursts of information arriving at precisely the same time as the receiver is substantially nonexistent.

The "maximum duration of operation" parameter is a preset time limit which is monitored by the microcontroller processor. The expiration of this parameter causes the badge to switch to another operating mode. This parameter allows the system administrator to limit the time of usage of the badge dependent upon the user. This parameter is also useful for automatically turning off the badge after a certain time of operation to conserve battery power.

The "card out duration" parameter is the amount of time which is monitored when the personnel card is removed from the badge. The expiration of the card out duration will cause the badge unit to turn off or switch to another operating mode.

The "maximum number of transmissions" is a count value which is decremented each time a badge transmits. When this value reaches zero, the badge unit will, depending on the preset mode of operation, halt all transmissions, alert the user of the condition, and/or switch to another preselect operation mode.

The "length of ID" allows the user to adjust the transmission of the length of ID to include other pertinent information. The RAM database stores information including the identification of the badge, which may be a person's social security number or telephone number. Other information stored in the database may include data pertinent to the wearer of the badge, such as a patient's medical status or history. The microcontroller **101** may retrieve any stored data and transmit it from the badge.

Badge Software

According to the preferred embodiment of the present invention, the software programs of the badge are downloaded into the ROM during initialization from an external device such as the base. Alternatively, the programs may be preprogrammed in the ROM prior to its installation in the badge. Each badge is preassigned a classification code. The type of programs downloaded from the base to each badge may vary according to different classifications. For example, doctors and nurses may have different classifications than patients. Employees and visitors may also be classified differently. Exemplary operational programs downloaded into the ROM include: badge/external data entry unit interface; badge operation; and parameter monitoring/control.

Basic Badge Operation

FIG. **3** is an illustration of an exemplary flow diagram of the operation of the basic badge unit. Each badge is initialized prior to its entry into the locator system. At initialization, the software programs of the badge are downloaded from the base in accordance to the badge's classification (step **301**). In the preferred embodiment, the badge is assigned a classification which is stored in the ROM. The classification is retrieved from the badge by the base and software programs are downloaded from the base. Alternatively, the personnel card may be a smart card having stored

information including the name or classification of the card owner. A smart card such as the one-chip-card, manufactured by Dai Nippon Printing Company LTD. may be used. The classification information is read from the card by the base through the edge connector **103** prior to initialization or download of the software programs to the badge memory. The operational parameters are also downloaded to the RAM. The badge is given an ID code which identifies the wearer of the badge. The ID is entered into the central computer **10** and/or the PBX **50**.

After initialization, the "rate of transmission" value is retrieved, loaded into a counter and decremented to zero (step **302**). The microcontroller processor then checks the card switch **105** for an open condition, signaling that the personnel card has been inserted into the badge unit (step **303**). If the switch is open, the processor executes the "transmit ID" routine, which includes the steps of retrieving the ID data from the RAM memory, adding the proper transmission signal codes, converting the data to a serial format, and forwarding the data to the transmitter **102** for transmission (step **304**). After transmission, the "maximum number of transmission" counter is decremented (step **305**) and the counter value is checked (step **306**). If the counter is zero, the badge halts further transmission (step **307**). If it is not zero, the badge returns to the timeout/transmission loop (steps **302** and **303**). If at any time the personnel card is removed, the removal is detected after the rate of transmission timeout. The processor then retrieves the card out duration value and commences to count down to zero (step **308**). During the count down, transmission is halted and the card switch **105** is checked after each decrement until the card out duration value reaches zero (step **309**). If the personnel card is inserted at any time before the card out duration reaches zero, the badge returns to the timeout/transmit loop (steps **302** and **303**). If the card out duration reaches zero, the badge operation is stopped (step **307**). The badge enters a sleep mode (step **311**). A sleep counter is decremented and the processor is turned off. When the counter reaches zero, the processor wakes up or is turned on. The processor checks for possible tasks and if no task is pending, the processor restarts the sleep counter and returns to sleep.

Transmitter

FIG. 4 illustrates the components of the transmitter **102** according to the preferred embodiment of the present invention. The transmitter **102** receives a serial data bit stream to be transmitted from the microcontroller **101**. The FM generator **401** generates a carrier signal which is frequency modulated by the serial data. The modulated signal is fed to an LED driver **402** for providing current driving capability to LEDs **403**. According to the preferred embodiment, the LEDs **403** emit infrared signals. The FM infrared signal transmission technique is known to one skilled in the art. See, for example, the descriptions of an FM infrared transmitter/receiver in U.S. Pat. No. 4,977,619 to J. Crimmins. The disclosure of the 4,977,619 patent is incorporated by reference herein. It is also understood to one skilled in the art that other known wireless data transmission techniques may be used, e.g. RF transmission.

Receiver

FIG. 5 illustrates the components of a receiver such as any of receivers **11**, **12** or **13** according to the preferred embodiment of the present invention. Infrared light sensitive diodes **510** receive the infrared signals transmitted from a transmitter **102** of a badge. Waveshaper and amplifier **520** conditions and amplifies the signals generated by the diodes **510**. The Waveshaper and amplifier **520** includes a plurality

of operational amplifiers for detecting the energy level of the received signal. The operational amplifiers are connected as comparators which are set at different thresholds. The comparators are monitored by the microprocessor **540** for determining the energy level of the signal received. FM receiver **530** demodulates the data from the carrier signal. Microprocessor **540** receives the serial data from the FM receiver **530**. According to the preferred embodiment of the present invention, the receiver is capable of receiving infrared transmissions from badge units up to a distance of 30 feet. The microprocessor **540** extracts the information including the badge ID from the received data. The extracted data is reformatted and forwarded in a message to the central computer **10** or the PBX **50** or both. Preferably, a 64180 microprocessor, commercially available from Motorola, Inc., is used. It is apparent to one skilled in the art that any microprocessor having equivalent performance characteristics may also be used.

Badge to Receiver Transmission

The data format of the transmission between the badge and the receiver according to the preferred embodiment of the present invention is now described. Again referring to FIG. 3, when the badge operation software routine reaches step **304**, the processor in microcontroller **101** fetches the data to be transmitted from the RAM memory location recognized to have the stored data for transmission, e.g., the badge identification number. The processor adds the necessary control and signaling information and formats the data in eight bit bytes plus a start and stop bit. An exemplary data burst is as follows:

START /	CONTROL & PARITY /				ID			/STOP	
1	2	3	4	5	6	7	8	9	10
START /			ID					/STOP	
1	2	3	4	5	6	7	8	9	10

The control and parity field (e.g., bits 2 to 5 of the first byte) identifies the type of data to follow. For example, a fixed or a variable length data. A fixed length data may be known in the system as 5 bytes long. If the data is variable length, the length of data to be transmitted is identified in the control field. Parity information may also be included in this field.

The formatted data is forwarded serially from the microcontroller **101** to the transmitter **102** for transmission to a receiver. The data transmission duty cycle is selectable and preassigned, i.e., both the data transmission rate and the period between each data burst are selectable parameters and are preset during initialization. Preferably, the data is selected to transmit to the receiver at a rate of 19.2 khz and the time between each data burst (transmission period) is one to five seconds. The transmission period may vary between milliseconds to hours.

Receiver to Central Computer Communication

The information received from the badges including the badge ID is communicated to the central computer **10** or PBX **50** at selected intervals by each of the receivers connected to the location system. Depending on the configuration of the receiver, the format of the messages to the central computer may be:

header/energy level/badge data received (1)

or

header/receiver location/badge data received (2)

Message type (1) includes an indication of the detected energy level of the signal received from the badge unit. This

message format is used when the location of each receiver is already known to either the PBX 50 or the central computer 10. According to an alternate embodiment of the present invention in which the receiver messages are sent to the central computer 10 through the PBX 50. The alternative embodiment may be conveniently configured since the PBX 50 is already wired to all the telephones throughout the facility and has processing and database capabilities to communicate with the telephones. In such a configuration, the receivers may be connected and communicated to as if they are telephones. The PBX 50 is capable of identifying the location of each receiver or telephone. In the alternate embodiment configuration, the PBX 50 adds the location information of the receiver from which a message has just been received and forwards a new data packet to the central computer 10. The central computer 10 receives messages from each receiver, either directly or through the PBX 50, on a substantially periodic basis and processes the identification and location information. The processed information is updated in memory and retrieved when information about a particular badge or ID is requested by the user.

Message type (2) may be used in messages sent directly from the receivers to the central computer 10. This message type is especially useful when satellite receivers (not shown) are connected to a standard receiver, preferably in a token ring network. Satellite receivers may include lesser components than a standard receiver but is capable of receiving signals from badges and relaying the information to a standard receiver for communication with the central computer 10. The satellite receivers may be more widely and conveniently distributed throughout the facility. The receiver connected to the satellite receiver may act as the hub and periodically polls the satellite receivers for information. The receiver then reports all the satellite receiver information in a reformatted message to the central computer 10.

External Control of the Badge

According to the preferred embodiment, the badge unit according to the present invention may be controlled by an external device (e.g., the base) to transmit data from the external device. When the microcontroller 101 detects an active signal at the "In Base" input at the edge connector 103, the microcontroller 101 relinquishes control of the transmitter 102 and bypasses data input from the external device to the transmitter 102 for FM conversion and transmission in infrared. Any device having a RS232 interface may input data to the badge. For example, a heart rate monitoring equipment may transmit heart rate monitoring date to the central computer 10 through the badge in such a way.

Bracelet Unit

As previously discussed, the electronics and software heretofore described for the basic badge unit is also applicable to the bracelet unit. FIG. 6A illustrates the bracelet embodiment according to the present invention. The bracelet may be strapped on the wrist or the ankle of a personnel such as a patient or a baby in a hospital. The bracelet includes an interlock wire 601 which forms a closed circuit when the bracelet is in the closed position. This circuit is monitored by the microcontroller 101 and if the bracelet is opened, the microcontroller 101 senses the open condition and reports such condition to the receiver.

The electronics as shown in FIG. 2 are integrated in a housing which may be removably attached to the bracelet. FIG. 6B illustrates the top view of the housing. FIG. 6C is the top view of the bracelet housing with the cover opened, exposing the electronic components therein. FIG. 6D is a side view of the bracelet housing. The dimension of the housing is no larger than 2.0" in length, 1.25" in width and 0.44" in thickness. The bracelet unit housing is preferably hermetically sealed and therefore waterproofed. The software programs are loaded into the ROM of microcontroller 101 prior to its installation in the bracelet housing. In the alternate embodiment, the bracelet unit does not mate with a personnel card and the card switch 105 is not used. The edge connector 103 is also eliminated to conserve space. Data can be read into the bracelet unit by strobing the light sensitive LED 108.

Enhanced Badge Unit

FIG. 7 illustrates a block diagram of a alternate embodiment of the badge unit according to the present invention. This embodiment is an enhanced version of the basic badge unit as shown in FIG. 1. The enhanced badge unit includes all the operations previously described for the basic badge unit and further includes: an infrared receiver 701 for receiving information; a card reader 702 for reading information stored in the smart card; a voice circuit 703 for receiving voice signals from speaker 704 and for translating digital signals to audio signals received from microphone 705; a keypad 706 for keypad entry of data; a display 707 for displaying information such as data entered from the keypad 706 or data received from the receiver 701; and a membrane switch (not shown) for special designated functions such as an emergency call or sending a selected message.

The receiver 701 includes infrared light sensitive diodes 510, waveshaper and amplifier 520 and FM receiver 530 as shown in FIG. 5 for receiving infrared transmission. The received data is read into the microcontroller 101 in a serial fashion. The voice circuit 703 includes PCM encoder and decoder, digital to analog converter and analog to digital converter. Voice signals input at the microphone 705 are digitized by the analog to digital converter and encoded by the PCM encoder. The PCM data is input to microcontroller 101 for processing including storage in a memory or transmission via the transmitter 102. In the enhanced badge unit, a digital signal processor is used as the microcontroller 101. The digital signal processor includes the components of a microcomputer including RAM and ROM memory and is capable of compressing the digitized data prior to the storage in its RAM memory. Preferably, the GASM algorithm standard for converting speech signals into a 13 kbps digital bit stream is used. Similarly, if voice data is to be output to speaker 704, the data stored in the RAM memory will be retrieved, decompressed, forwarded to voice circuit 703, which decodes the PCM data, converts the digital data to analog data, then to audio signals through speaker 704. The digital signal processor may be the ADSP-21MSP50, manufactured by Analog Devices, or any other comparable DSPs commercially available.

In the enhanced system embodiment according to the present invention, each of the receivers 11, 12 and 13 includes an infrared transmitter, having electronics substantially as shown in FIG. 4, for transmitting infrared signals for reception by the enhanced badge units within the reception range of the badge receiver 701. A typical usage of the enhanced system involves the location of a badge wearer and communication of a message by the central computer 10 or PBX 50 to the badge wearer via the receive unit (11, 12 or 13) closest to the enhanced badge unit. The message received by the enhanced badge may be displayed on display 707 or converted to voice by voice circuit 703 and/or announced over speaker 704. The badge wearer can in turn reply by speaking into the microphone 705. The voice circuit 703 digitizes the analog signal for the microphone 705 and

the microcontroller **101** adds the necessary control information prior to transmission of the message through the transmitter **102** to the receivers **11**, **12** or **13**, which in turn transmits to the central computer **10** or PBX **50**. The badge wearer may also reply by entering a text message via the keypad **706**.

Exemplary software program commands and specifications suitable for usage in accordance with the locator system of the present invention is attached as the appendix.

It should be understood that various changes and modifications to the preferred embodiments described above will be apparent to those skilled in the art without departing from the spirit and the scope of the invention. These changes and modifications are intended to be covered by the following claims.

We claim:

1. A badge for use in an object location and information retrieval system for locating within a facility an object coupled to said badge and obtaining information stored in said badge, said system having a central computer, a plurality of receivers disposed at spaced apart areas within said facility, each of said receivers being capable of receiving signals from said badge and communicating signals including the identification of said badge to said central computer, said badge comprising:

a transmitter for transmitting signals including a unique identification signal of said badge;

an on/off switch;

manual select means for selecting one of a plurality of operating modes;

a microcontroller having a processor, associated memory and stored programs, said memory having a database with stored information including a plurality of operational parameters and a plurality of records specific to said object being coupled to said badge, said stored programs being executed by said processor for controlling badge operations including the control of said transmitter depending upon the processing of said parameters;

means in said processor for accessing information from said database in said memory and for forwarding said information to said transmitter for transmission to one of said plurality of receivers;

a receiver;

display means for displaying information received by said receiver, transmitted by said transmitter, and stored in said memory database;

an audio interface having a voice circuit and a microphone, said voice circuit having amplification means and digital conversion means for converting digital signals into voice signals and for amplifying said voice signals for playing over a speaker, said microphone having voice digitization means for digitizing voice signals for transmitting said voice signals via said transmitter to one of said plurality of receivers; and

a data interface for interfacing with an external processing device for reading data from said memory database or entering data including operational parameter values into said memory database.

2. A badge according to claim **1** wherein said transmitter transmits infrared signals.

3. A badge according to claim **1** wherein said plurality of operational parameters include the period of transmission of said signals.

4. A badge according to claim **1** wherein said plurality of parameters include the duration of transmitter operation.

5. A badge according to claim **4** wherein said transmitter operation duration is monitored by said microcontroller and upon the expiration of said duration, said microcontroller switches to another mode of operation.

6. A badge according to claim **5** wherein said another mode of operation include erasing the contents of said database in said memory.

7. A badge according to claim **5** wherein said another mode of operation include turning off said transmitter.

8. A badge according to claim **5** wherein said another mode of operation include changing the identification signal of said badge.

9. A badge according to claim **1** further including a counter for counting the number of transmissions transmitted from said transmitter.

10. A badge according to claim **1** wherein said identification of said badge is a person's social security number.

11. A badge according to claim **1** wherein said database in said memory includes medical status information of a person.

12. A badge according to claim **1** further including a rechargeable battery and means for recharging said battery.

13. A badge according to claim **1** further including a housing, said housing including a slot for slidingly mating with a personnel card.

14. A badge according to claim **13** further including a switch for turning off said transmitter when switch is in an open position, said switch is opened upon the removal of said personnel card.

15. A badge according to claim **13** wherein said personnel card includes stored data including identification data and said badge includes means for accessing said stored data.

16. A badge according to claim **1**, wherein said receiver receives infrared signals.

17. A badge according to claim **1** wherein said central computer is coupled to an LAN for coupling to a plurality of processing units for communication with said central computer.

18. A badge according to claim **1** wherein said central computer is coupled to a PBX for coupling to a plurality of telephones.

19. A badge according to claim **18** wherein the location information of a badge to be located within said facility is retrievable by dialing the identification of said badge to be located from any of said plurality of telephones coupled to said PBX.

20. A badge according to claim **1** wherein said data interface includes a bidirectional connection for facilitating communication between said external processing device and said microcontroller.

21. A badge according to claim **1** wherein said external processing device is a keypad.

22. A bracelet for use in an object location tracking and information retrieval system for locating within a location an object coupled to said bracelet and obtaining information stored in said bracelet, said system having a central computer, a plurality of receivers disposed at spaced apart areas within said location, each of said receivers being capable of receiving signals from said bracelet and transmitting signals including the identification of said bracelet to said central computer, said bracelet having a housing with electronics integrated therein, comprising:

a transmitter for transmitting signals including a unique identification signal of said bracelet;

a microprocessor having associated memory and stored programs, said memory having a database storage of a plurality of records about said object including the

identification of said object, said stored programs being executed by said microprocessor for controlling bracelet operations, said microprocessor further includes means for accessing information from said database in memory and for forwarding said information to said transmitter for transmission to one of said plurality of receivers;

a receiver;

display means for displaying information received by said receiver, transmitted by said transmitter, and stored in said memory database;

an audio interface having a voice circuit and a microphone, said voice circuit having amplification means and digital conversion means for converting digital signals into voice signals and for amplifying said voice signals for playing over a speaker, said microphone having voice digitization means for digitizing voice signals for transmitting said voice signals via said transmitter to one of said plurality of receivers; and

wherein said transmitter is preassigned with a duration of operation, said duration of operation is monitored by said microprocessor and upon the expiration of said duration, said microprocessor switches to another mode of operation.

23. A bracelet according to claim 22, wherein said integrated electronics is enclosed in the housing removably attached to said bracelet, said housing is less than 0.44 inches in thickness, 2.0 inches in length and 1.25 inches in width.

24. A bracelet according to claim 23 wherein said housing is waterproof.

25. A bracelet according to claim 22 wherein said bracelet includes means for receiving signals from an external data entry device and means for storing said received signals into said memory.

26. A bracelet according to claim 25 wherein said means for receiving signals is capable of receiving infrared signals.

27. A bracelet according to claim 22, further including:

means for forming a closed circuit when said bracelet is in a closed position; means for detecting an open condition when said bracelet is opened; and means for indicating said open condition when said open condition is detected.

28. A bracelet according to claim 22 wherein said transmitter transmits infrared signals.

29. A bracelet according to claim 22 wherein said stored information includes a plurality of operational parameters, said operational parameters being used in conjunction with said stored programs for controlling bracelet operations.

30. A bracelet according to claim 22 wherein said another mode of operation includes erasing the contents of said database in said memory.

31. A bracelet according to claim 22 wherein said another mode of operation includes turning off said transmitter.

32. A bracelet according to claim 22 wherein said another mode of operation includes changing the identification signal of said bracelet.

33. A bracelet according to claim 22 further including a counter for counting the number of transmissions transmitted from said transmitter.

34. A bracelet according to claim 22 wherein said identification of said bracelet is a person's social security number.

35. A bracelet according to claim 22 wherein said database in said memory includes medical status information of a person.

36. A bracelet according to claim 22 further including a rechargeable battery and means for recharging said battery.

37. A bracelet according to claim 22 further including a manual select button for selecting one of a plurality of operating modes of said bracelet.

38. An object location tracking and information retrieval system comprising:

a plurality of badges coupled to objects to be tracked, each of said badges including: wireless transmission means for transmitting signals including a unique identification signal; processor means having associated memory and stored programs, said memory having a database storage of a plurality of records specific to an object coupled to said badge and a plurality of operational parameters, said stored programs being executed by said processor means for controlling badge operations including the control of said wireless transmission means depending upon the processing of said parameters; means for interfacing with external means for reading and entering data including operational parameter values into said memory database; and means in said processor for accessing information from said database and for forwarding said information to said wireless transmission means;

a plurality of receivers disposed at spaced apart areas, each of said receivers including means for receiving said signals including said unique identification signals and said information accessed from said database transmitted from said wireless transmission means of said badges, and processor means for processing said received signals; and

central processing means for receiving messages from said plurality of receivers, said messages including said unique identification signals of said badges, and means for tracking the location of each of said plurality of badges each of said badges further includes: an on/off switch; manual select means for selecting one of a plurality of operating modes; a receiver; display means for displaying information received by said receiver, transmitted by said wireless transmission means, and stored in said memory database; and an audio interface having a voice circuit and a microphone, said voice circuit having amplification means and digital conversion means for converting digital signals into voice signals and for amplifying said voice signals for playing over a speaker, said microphone having voice digitization means for digitizing voice signals for transmitting said voice signals via said wireless transmission means to said plurality of receivers.

39. An object location tracking and information retrieval system according to claim 38, wherein said central processing means includes private branch exchange means for communicating with a plurality of telephones.

40. An object location tracking and information retrieval system according to claim 39, wherein said central processing means is coupled to a local area network for coupling to a plurality of processing units.

41. A badge according to claim 38 wherein said plurality of records within said database includes medical information.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,455,851 Page 1 of 3

DATED : Oct. 3, 1995

INVENTOR(S) : John Chaco, et al

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

On the title page of the issued patent, section "[56]" entitled "References Cited U.S. PATENT DOCUMENTS", after "455/99", insert:

-- 3,696,384	10/1972	Lester	367/117
3,805,227	4/1974	Lester	367/117
3,805,265	4/1974	Lester	367/117
4,225,953	9/1980	Simon et al.	367/117--;

after "340/312", insert:

-- 4,553,267	11/1985	Crimmins	455/607--;

after "340/543", insert:

-- 4,649,385	3/1987	Aires et al.	379/57
4,757,553	7/1988	Crimmins	455/607
4,835,372	5/1989	Gombrich et al.	235/375--;

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : **5,455,851** **Page 2 of 3**

DATED : **Oct. 3, 1995**

INVENTOR(S) : **John Chaco, et al**

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

after "340/825.49", insert:

-- 4,955,000	9/1990	Nastrom	367/117
4,977,619	12/1990	Crimmins	455/607--; and

after "379/57", insert:

-- 5,119,104	6/1992	Heller	342/450--.

In the section entitled, "FOREIGN PATENT DOCUMENTS", after "United Kingdom.", insert:

-- 2230365	10/1990	United Kingdom.--.

OTHER PUBLICATIONS

"Great New Product Infrared Locator", TELECONNECT, February 1986, 4 pages

Ooi, Lim & Lau, "Low Cost RF Identification and Locating System" IEEE Transactions on Consumer Electronics, Vol. 35, No. 4 Nov., 1989, pp. 831-839

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : **5,455,851** **Page 3 of 3**

DATED : **Oct. 3, 1995**

INVENTOR(S) : **John Chaco, et al**

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Mark Weiser "The Computer for the 21st Century", Scientific American, September, 1991, pp. 94-95, 98-100

"Infra-Com®", A Staff and Equipment Locating and Signaling System from United Identification Systems Corp., 8 pages

"Keeping Track of Alzheimer and Dementia Prone Patients Just Got Easier", Sycon, 5 pages

Sekurmed Sales Brochure, 5 pages

Signed and Sealed this

Twenty-third Day of April, 1996

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

US005426425A

United States Patent [19]

Conrad et al.

[11] **Patent Number: 5,426,425**

[45] **Date of Patent: Jun. 20, 1995**

[54] **INTELLIGENT LOCATOR SYSTEM WITH MULTIPLE BITS REPRESENTED IN EACH PULSE**

[75] Inventors: **Alexander Conrad**, Neptune Beach; **Charles Bell**, Jacksonville, both of Fla.

[73] Assignee: **Wescom, Inc.**, Jacksonville, Fla.

[21] Appl. No.: **957,662**

[22] Filed: **Oct. 7, 1992**

[51] **Int. Cl.^{6}** **G08B 5/22**; G08B 23/00; H04Q 1/39

[52] **U.S. Cl.** **340/825.49**; 340/825.44; 340/825.55; 340/573; 379/38

[58] **Field of Search** 340/825.49, 825.37, 340/286.07, 306, 994, 996, 573, 825.44, 825.55; 359/124, 143, 142, 154; 379/38, 39, 47, 104; 250/338.1

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IEEE, IEEE Standard Dictionary, on "burst" (Third Edition), 1984.

Primary Examiner—Donald J. Yusko
Assistant Examiner—David Jung
Attorney, Agent, or Firm—Clifford A. Poff

[57] **ABSTRACT**

A locating and monitoring system includes transmitters worn by a person, animal, or equipment to transmit an unique identification code while moving about a facility. The code is transmitted by pulse bursts at diverse times during predetermined time intervals to prevent synchronization with resident signals in the facility. Receivers in the walls or ceilings of the facility respond to the infrared radiation of the pulse bursts and validate the identification code by a checksum of the code through a comparison with a checksum transmitted with the code. The receivers deliver validated codes to arbitrators and receive back signals indicative of the level of an individual assigned to a class wearing the transmitters. Signals from the receivers are received by arbitrators which forward the codes to a CPU for recording start and stop events indicative of movement by transmitters into and out of the reception range of the various receivers.

13 Claims, 13 Drawing Sheets

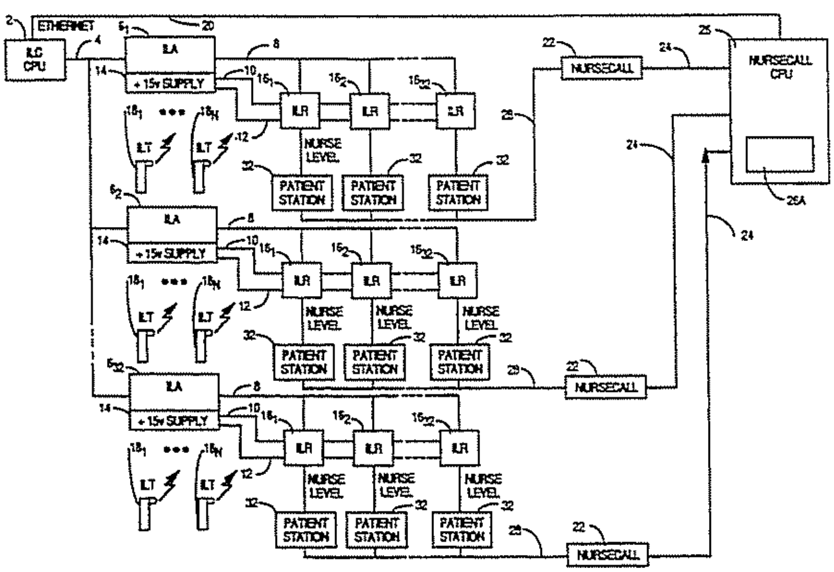
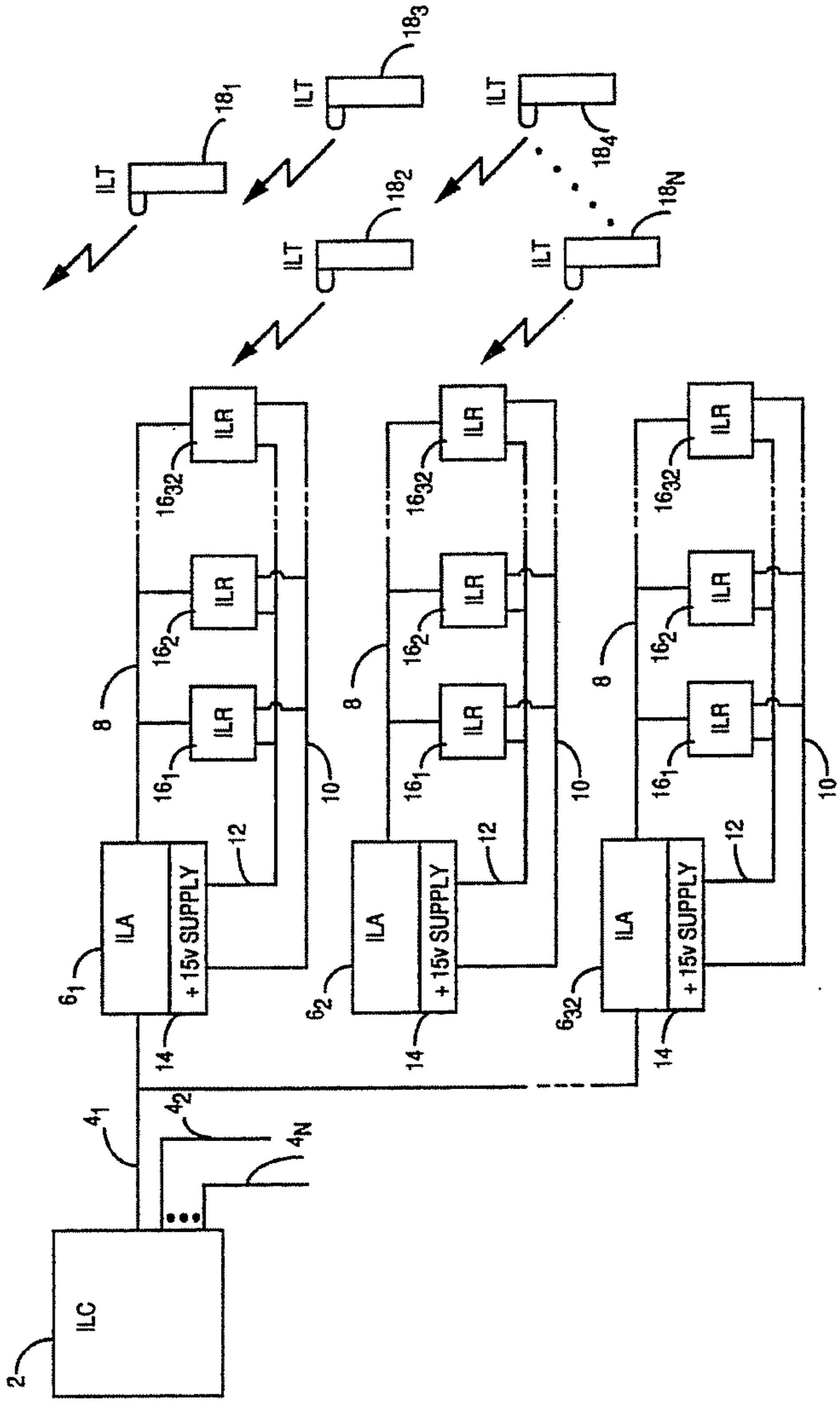


FIG. 1


ILT
ILT
ILT
ILT
ILT
ILR
ILR
ILR
ILR
ILR
ILR
ILR
ILR
ILR
ILA
+ 15v SUPPLY
ILA
+ 15v SUPPLY
ILA
+ 15v SUPPLY
ILC

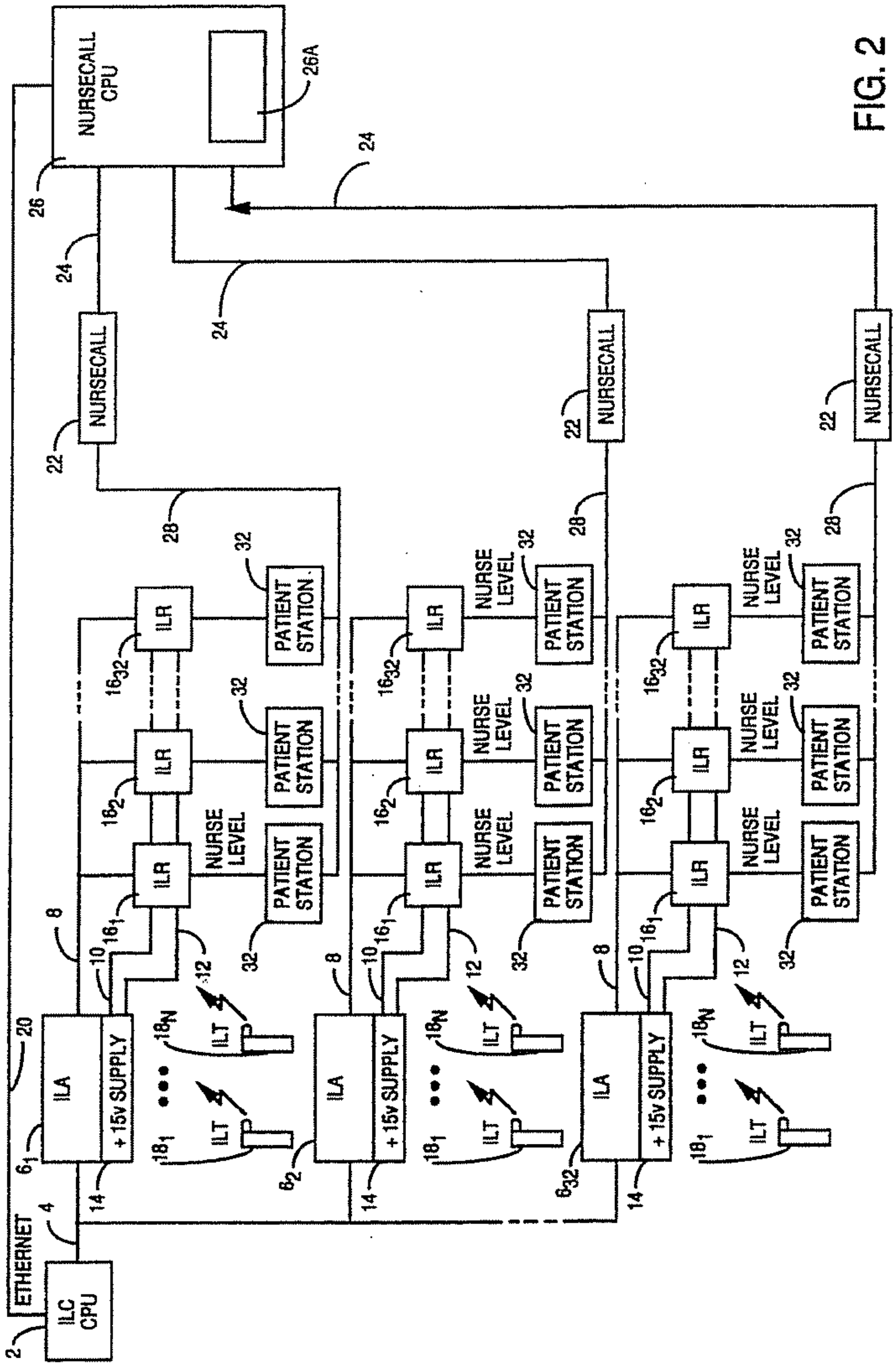

NURSECALL CPU
26A
26
24
NURSECALL
22
28
ILR
NURSE LEVEL
PATIENT STATION
32
16_1
16_2
16_{32}
ILA
+15v SUPPLY
ILT
18_1
18_N
6_1
6_2
6_{32}
8
10
12
14
20
4
ETHERNET
ILC CPU
2

FIG. 2

FIG. 3

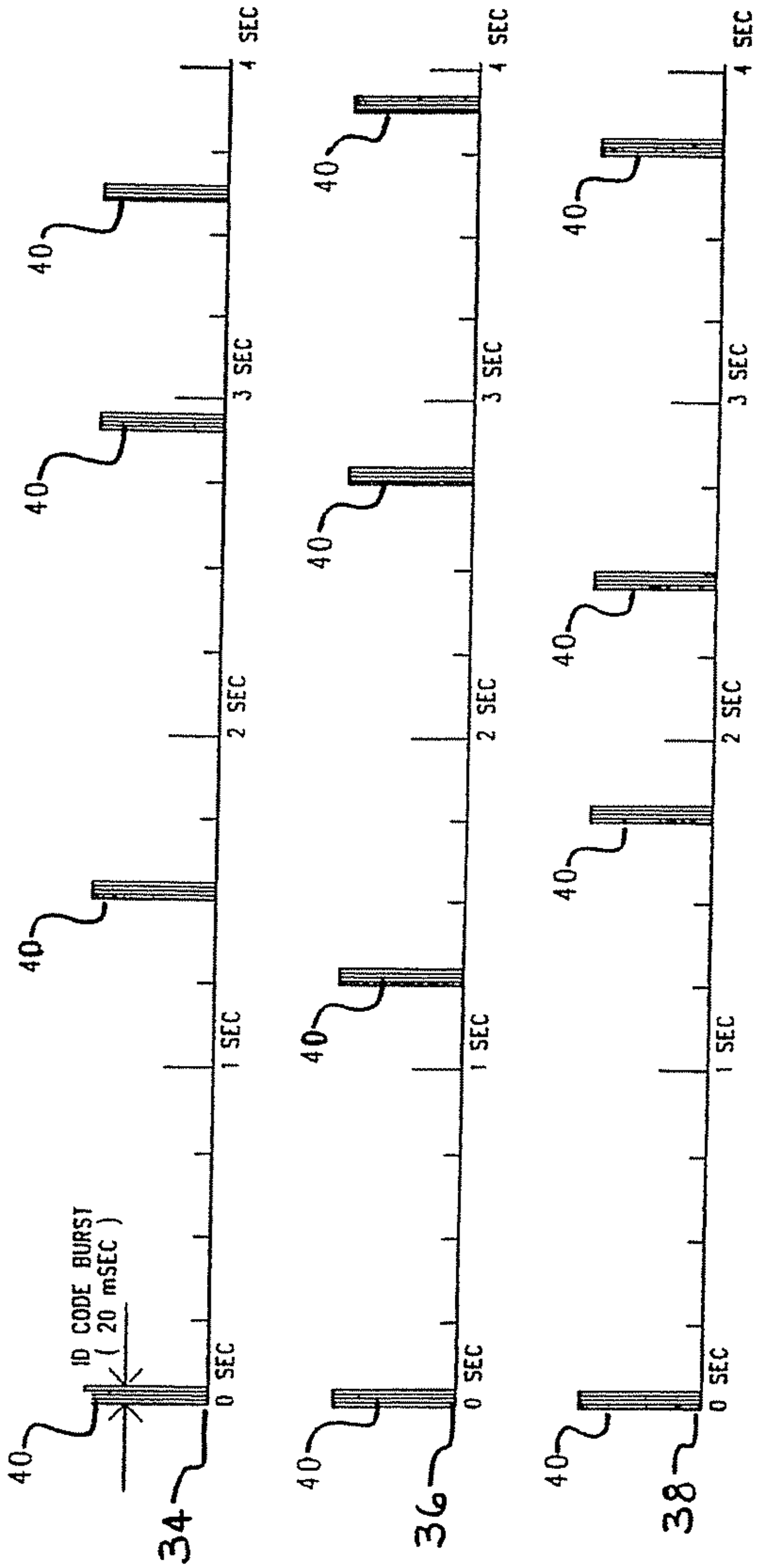
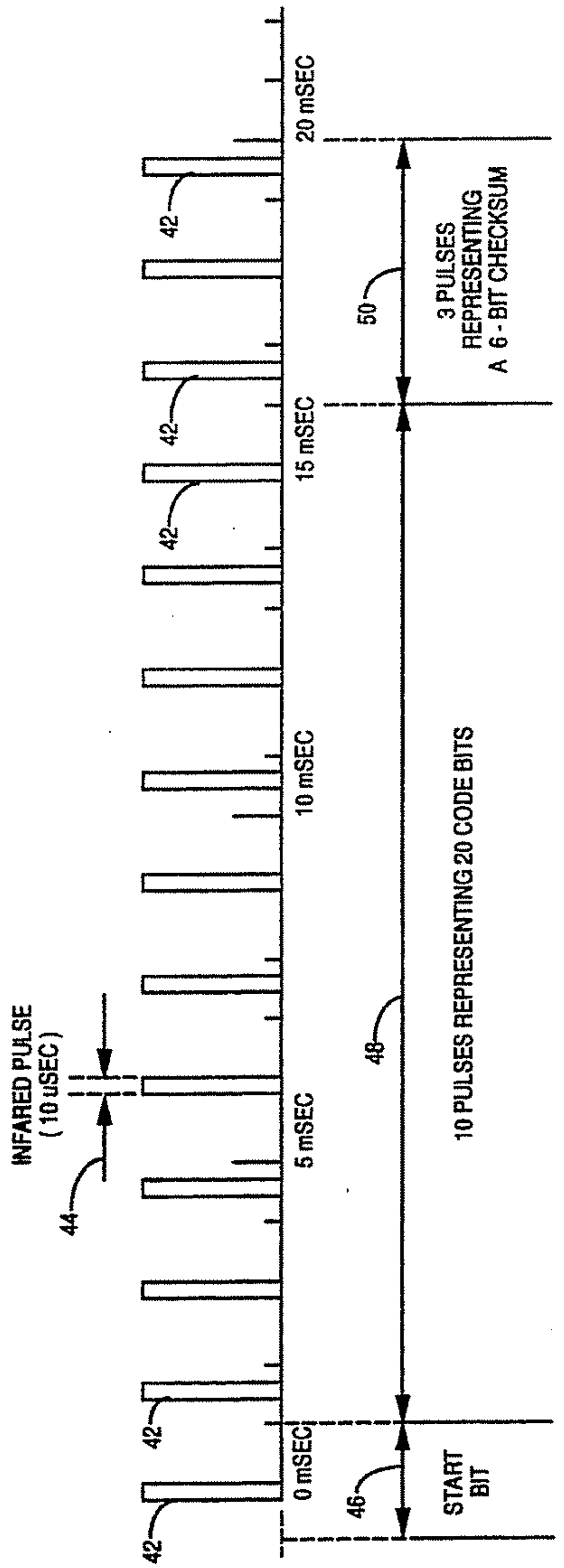
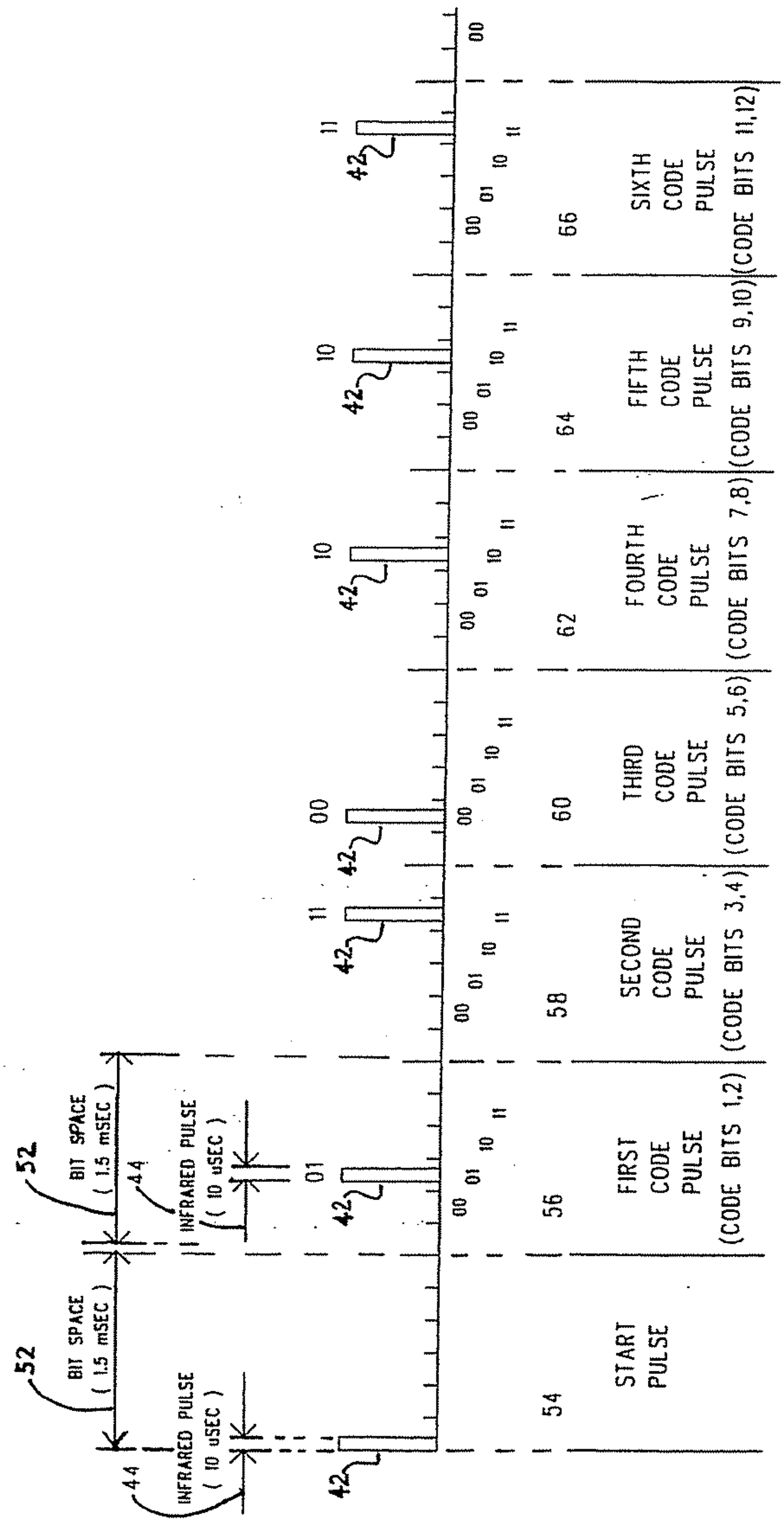


FIG. 4



20 mSEC
15 mSEC
10 mSEC
5 mSEC
0 mSEC
42
44
46
48
50
INFARED PULSE
(10 uSEC)
3 PULSES
REPRESENTING
A 6-BIT CHECKSUM
10 PULSES REPRESENTING 20 CODE BITS
START
BIT

FIG. 5



52
BIT SPACE (1.5 mSEC)
44
INFRARED PULSE (10 uSEC)
42
54
START PULSE
56
FIRST CODE PULSE (CODE BITS 1,2)
58
SECOND CODE PULSE (CODE BITS 3,4)
60
THIRD CODE PULSE (CODE BITS 5,6)
62
FOURTH CODE PULSE (CODE BITS 7,8)
64
FIFTH CODE PULSE (CODE BITS 9,10)
66
SIXTH CODE PULSE (CODE BITS 11,12)
00
01
10
11

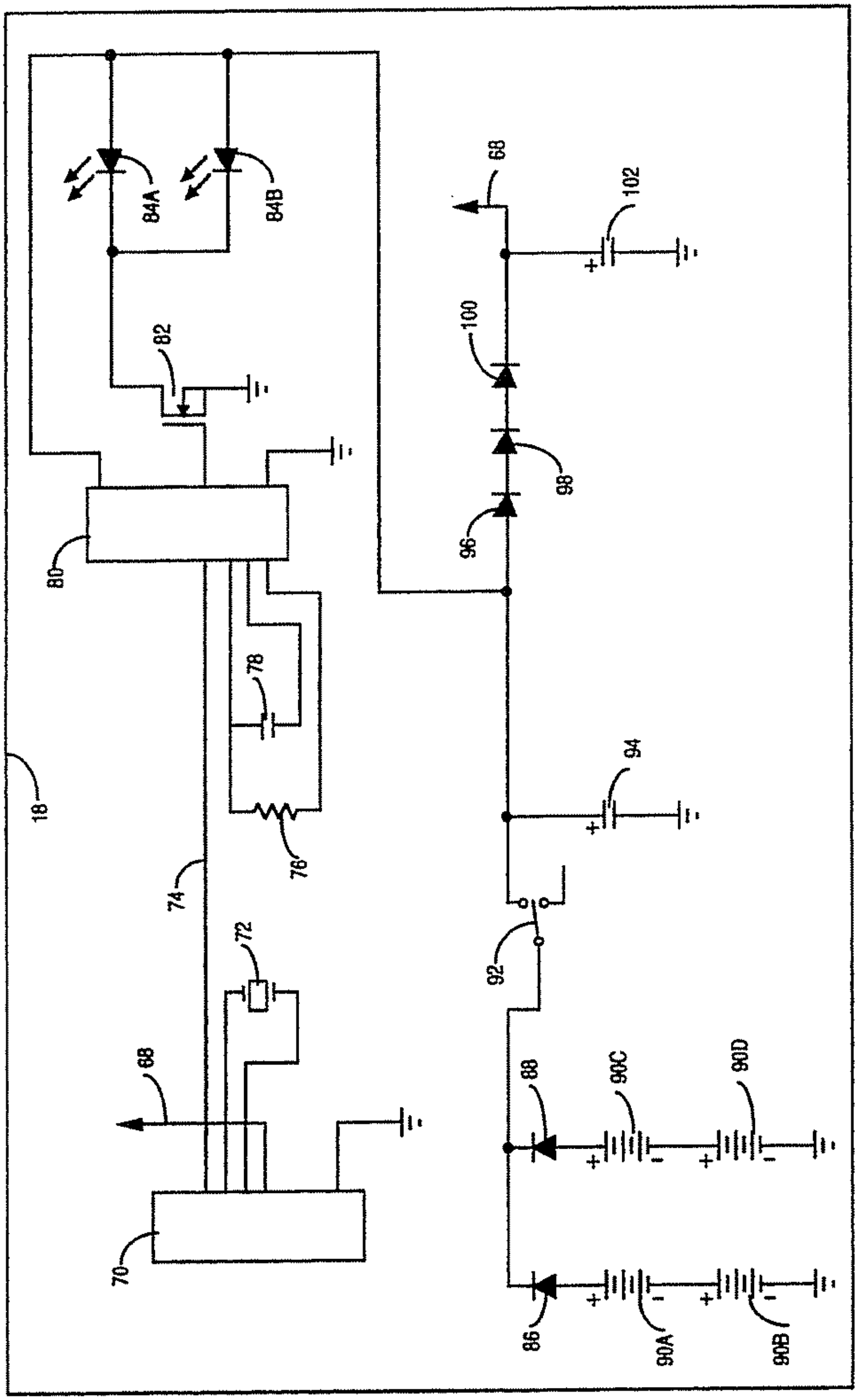

84A
84B
82
80
78
76
74
72
70
68
18
68
102
100
98
96
94
92
88
86
90A
90B
90C
90D

FIG. 6

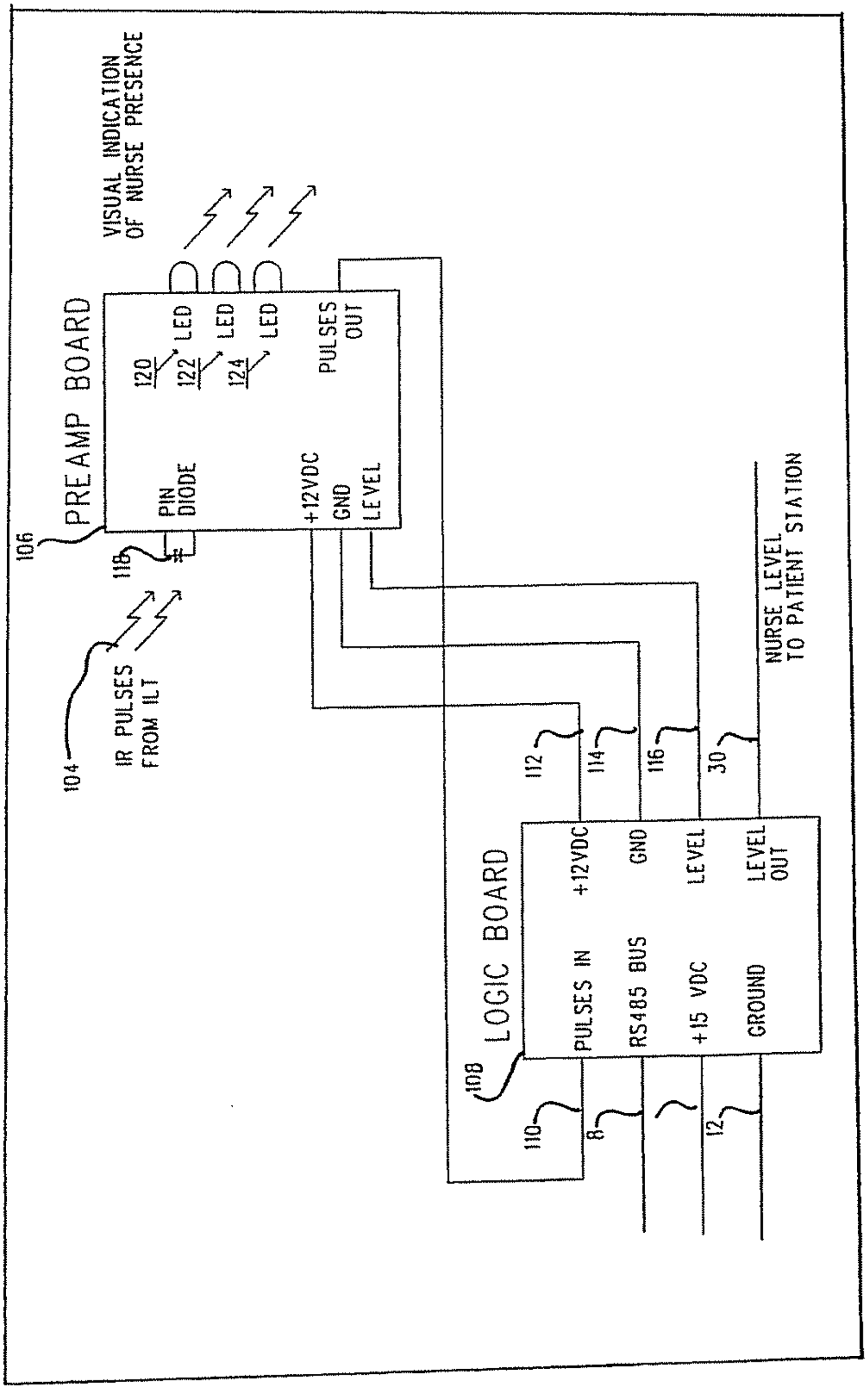

VISUAL INDICATION OF NURSE PRESENCE
PREAMP BOARD
106
PIN DIODE
118
120
122
124
LED
LED
LED
PULSES OUT
+12VDC
GND
LEVEL
IR PULSES FROM ILT
104
112
114
116
30
NURSE LEVEL TO PATIENT STATION
LOGIC BOARD
108
PULSES IN
RS485 BUS
+15 VDC
GROUND
+12VDC
GND
LEVEL
LEVEL OUT
110
8
12

FIG. 7

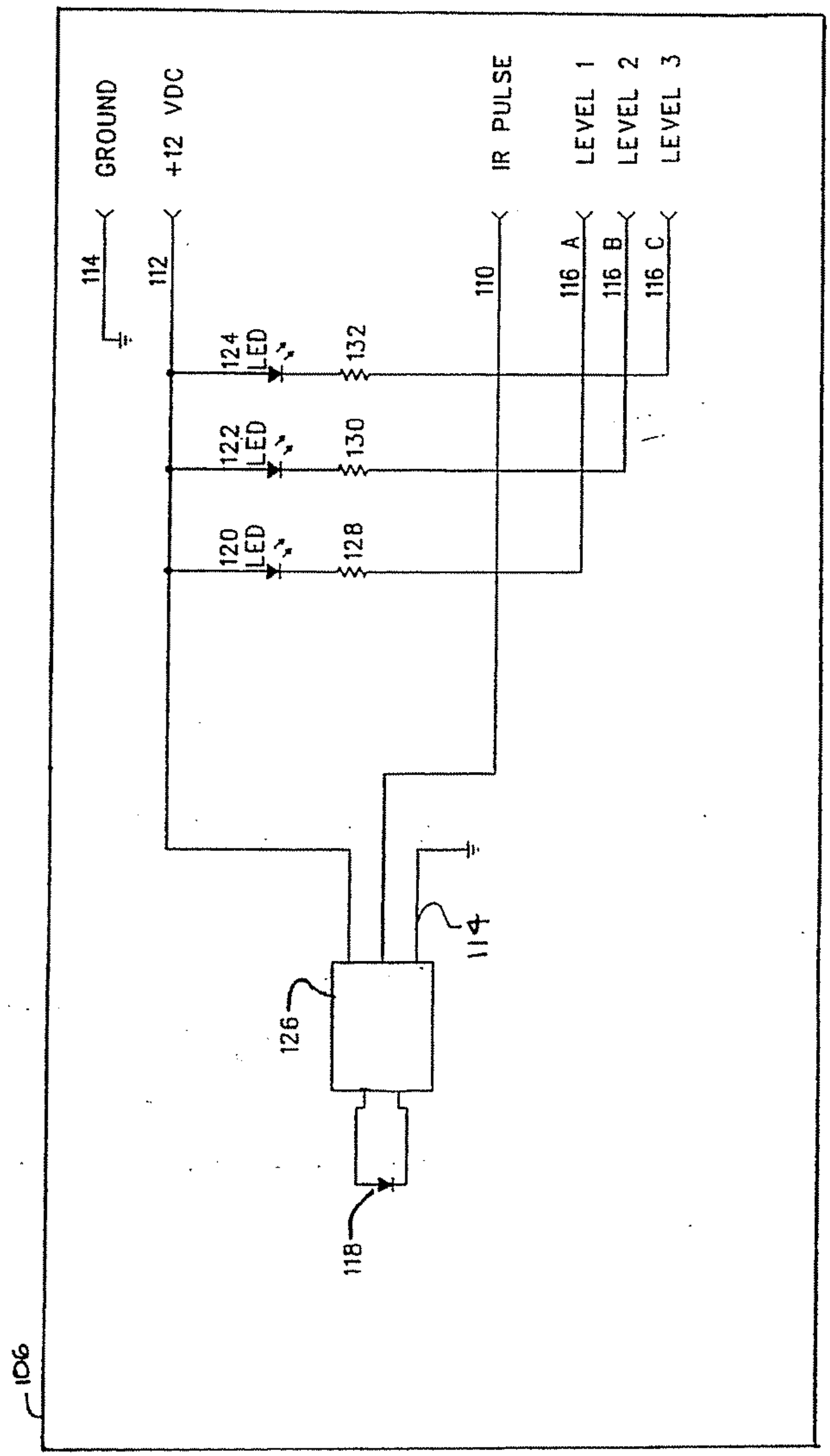
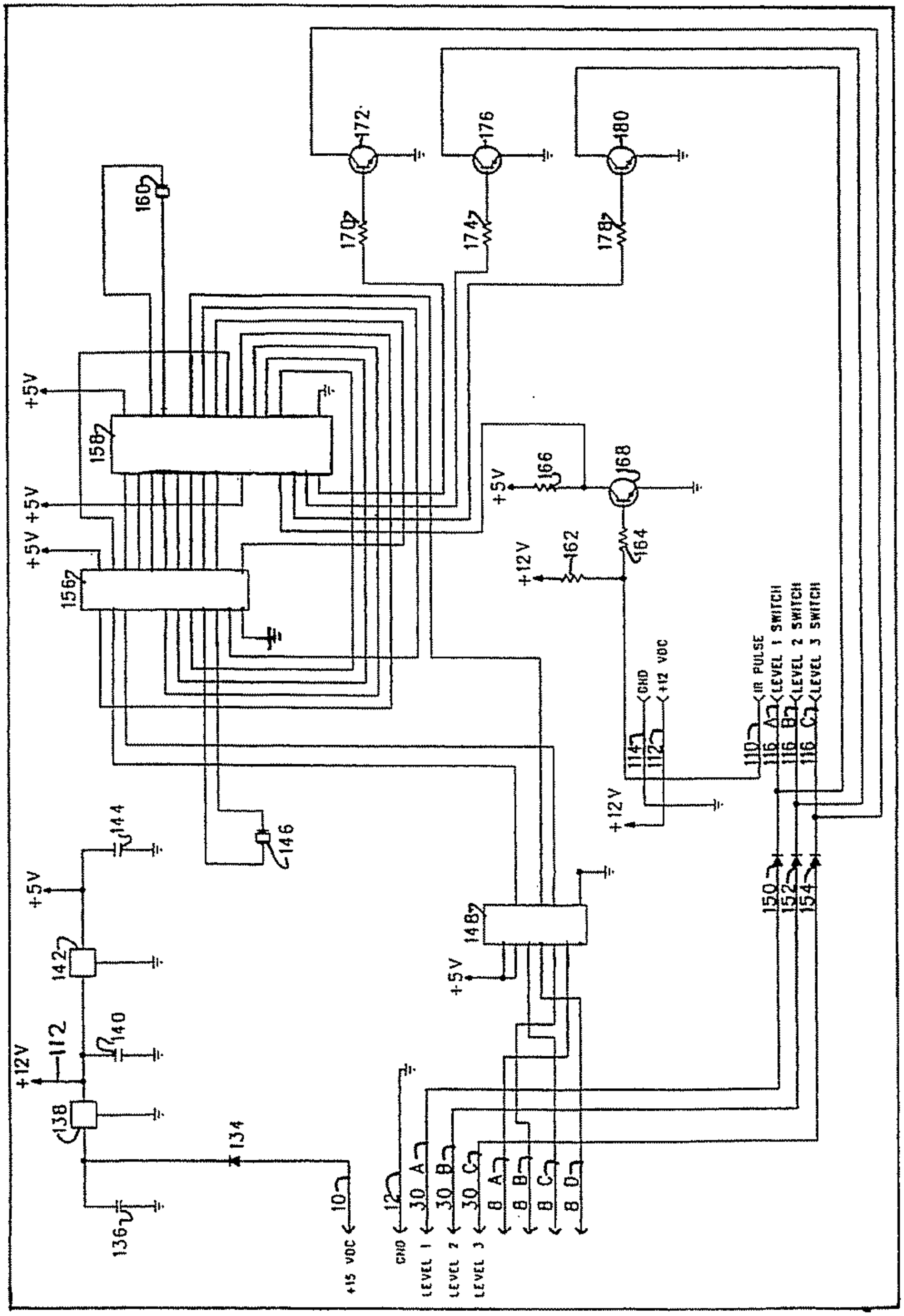
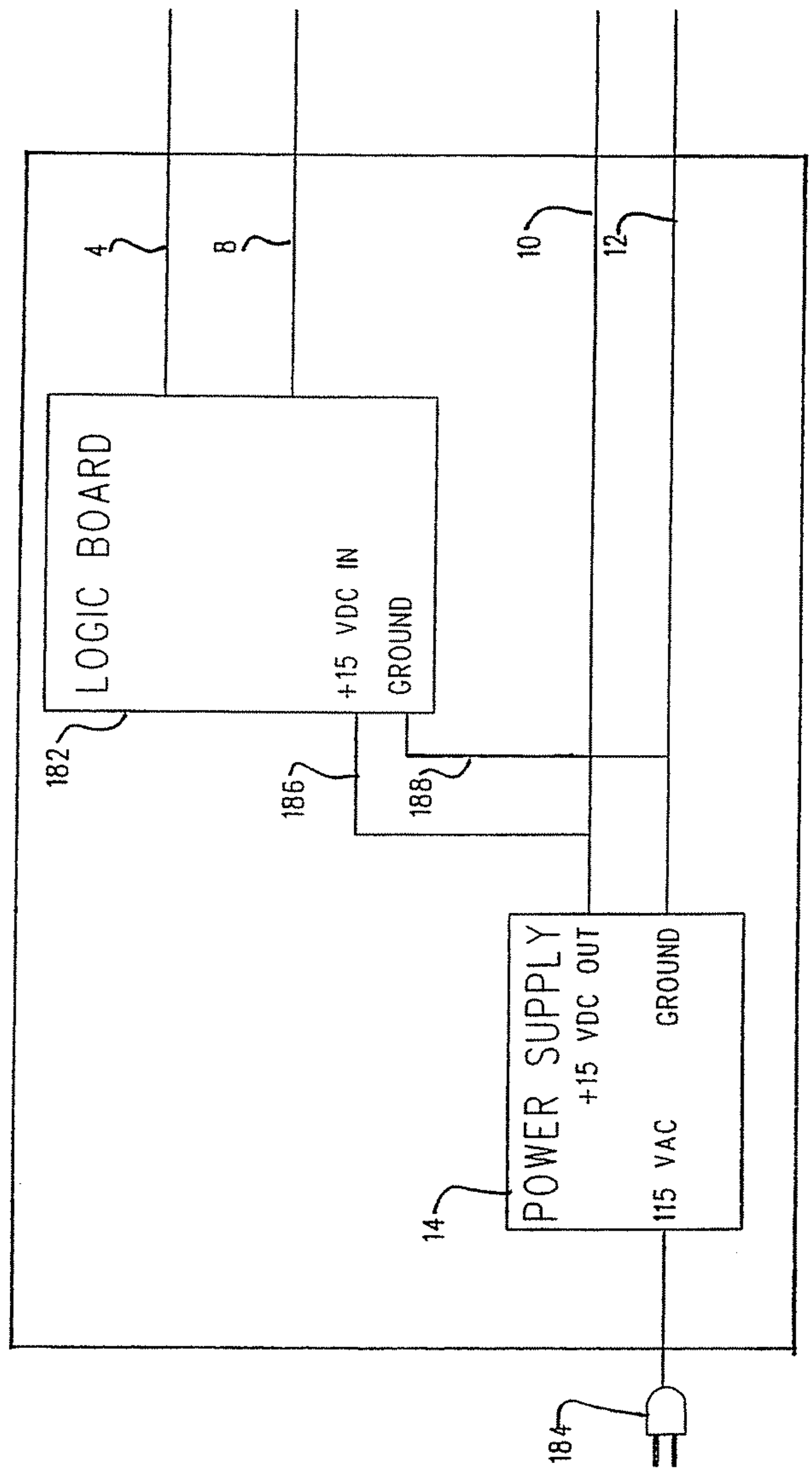

GROUND
+12 VDC
IR PULSE
LEVEL 1
LEVEL 2
LEVEL 3
114
112
110
116 A
116 B
116 C
124
LED
122
LED
120
LED
132
130
128
114
126
118
106

FIG. 8



+15 VDC
GND
LEVEL 1
LEVEL 2
LEVEL 3
IR PULSE
LEVEL 1 SWITCH
LEVEL 2 SWITCH
LEVEL 3 SWITCH
GND
+12 VDC
+5V
+12V

FIG. 9



LOGIC BOARD
+15 VDC IN
GROUND
POWER SUPPLY
+15 VDC OUT
GROUND
115 VAC
4
8
10
12
182
186
188
14
184

FIG. 10

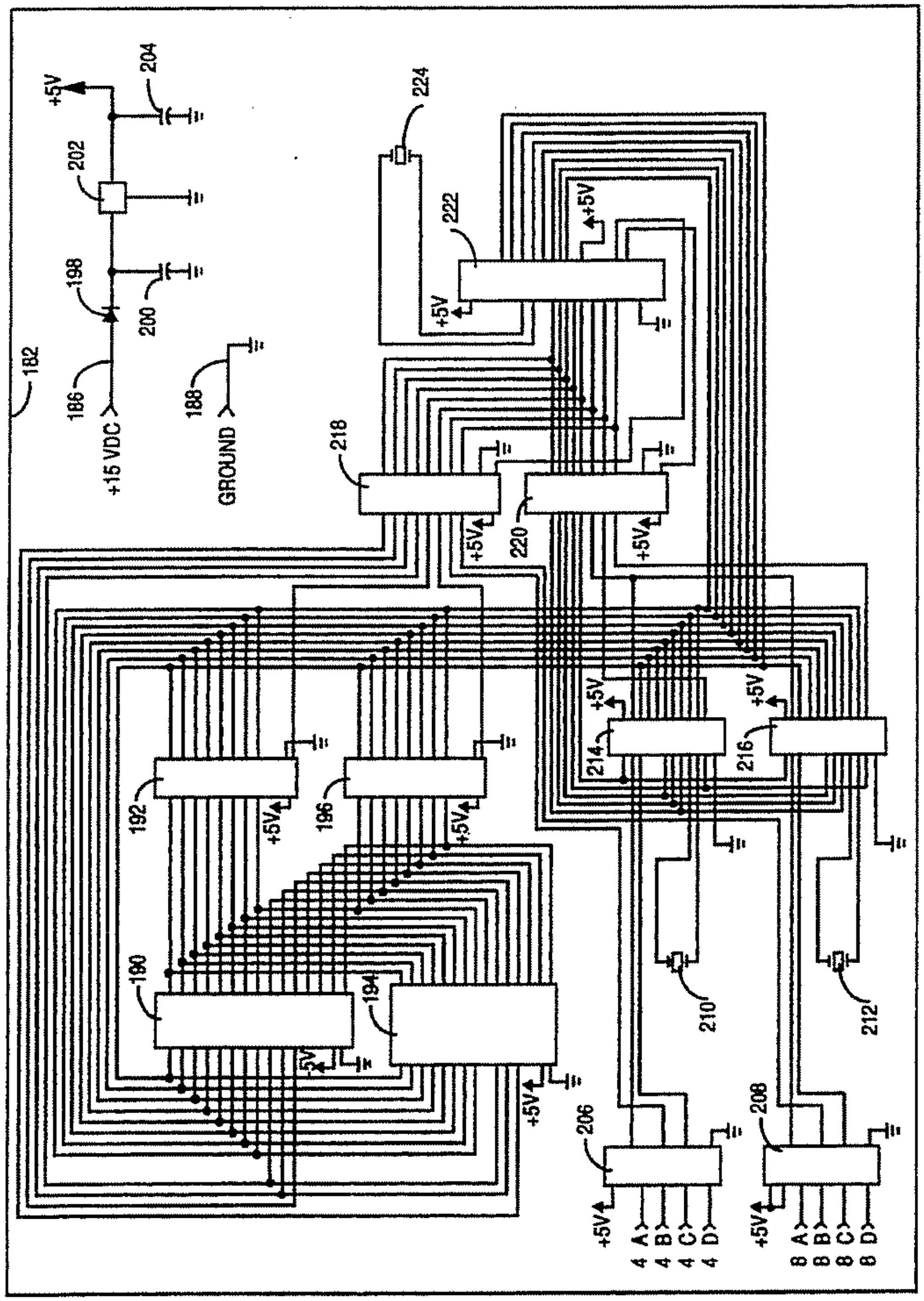

182
+15 VDC
186
GROUND
188
198
200
202
204
+5V
224
222
218
220
190
192
194
196
214
216
206
208
210
212
4 A
4 B
4 C
4 D
8 A
8 B
8 C
8 D

FIG. 11

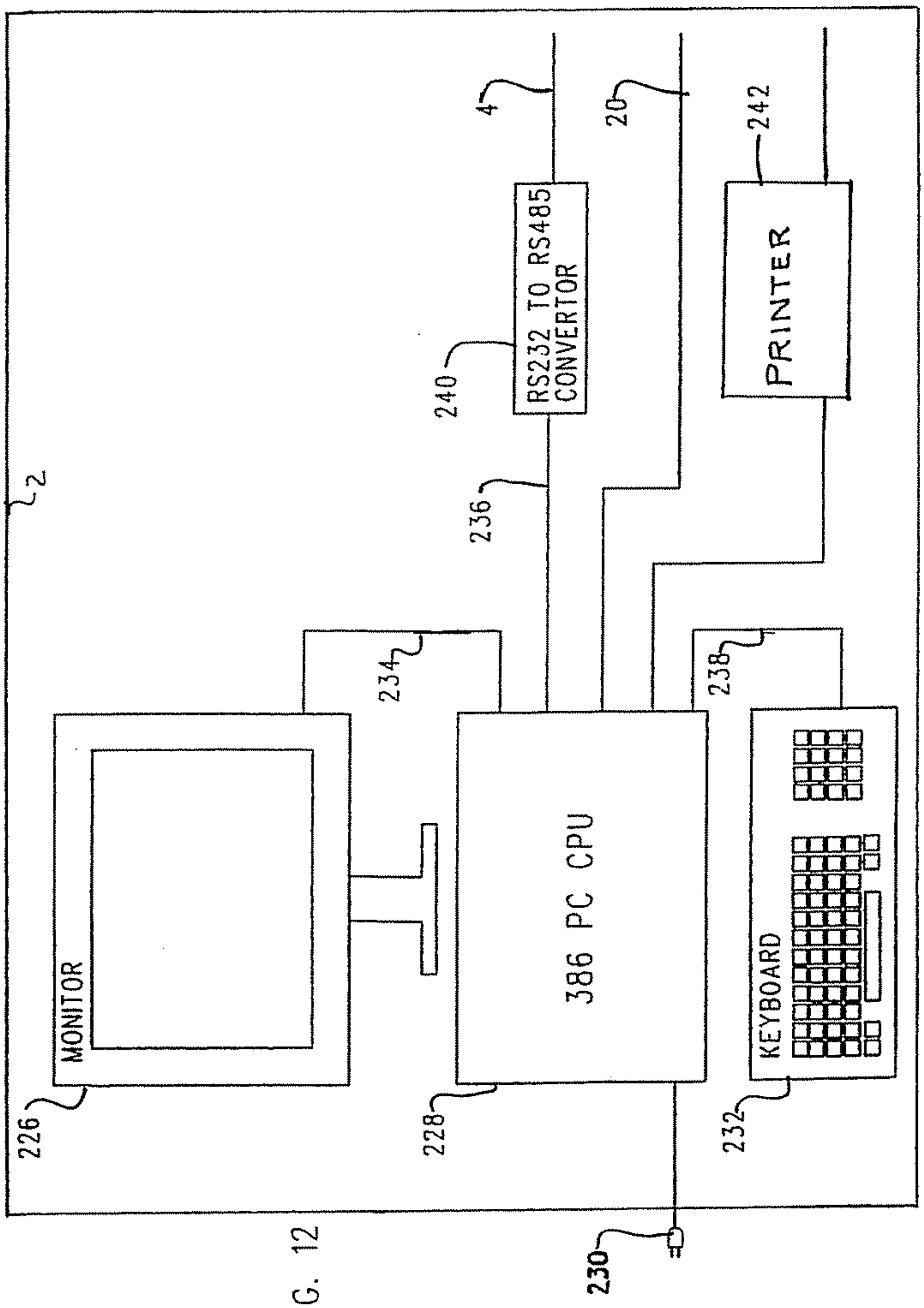

4
20
242
RS232 TO RS485
CONVERTOR
PRINTER
240
2
236
234
238
MONITOR
386 PC CPU
KEYBOARD
226
228
232
230

FIG. 12

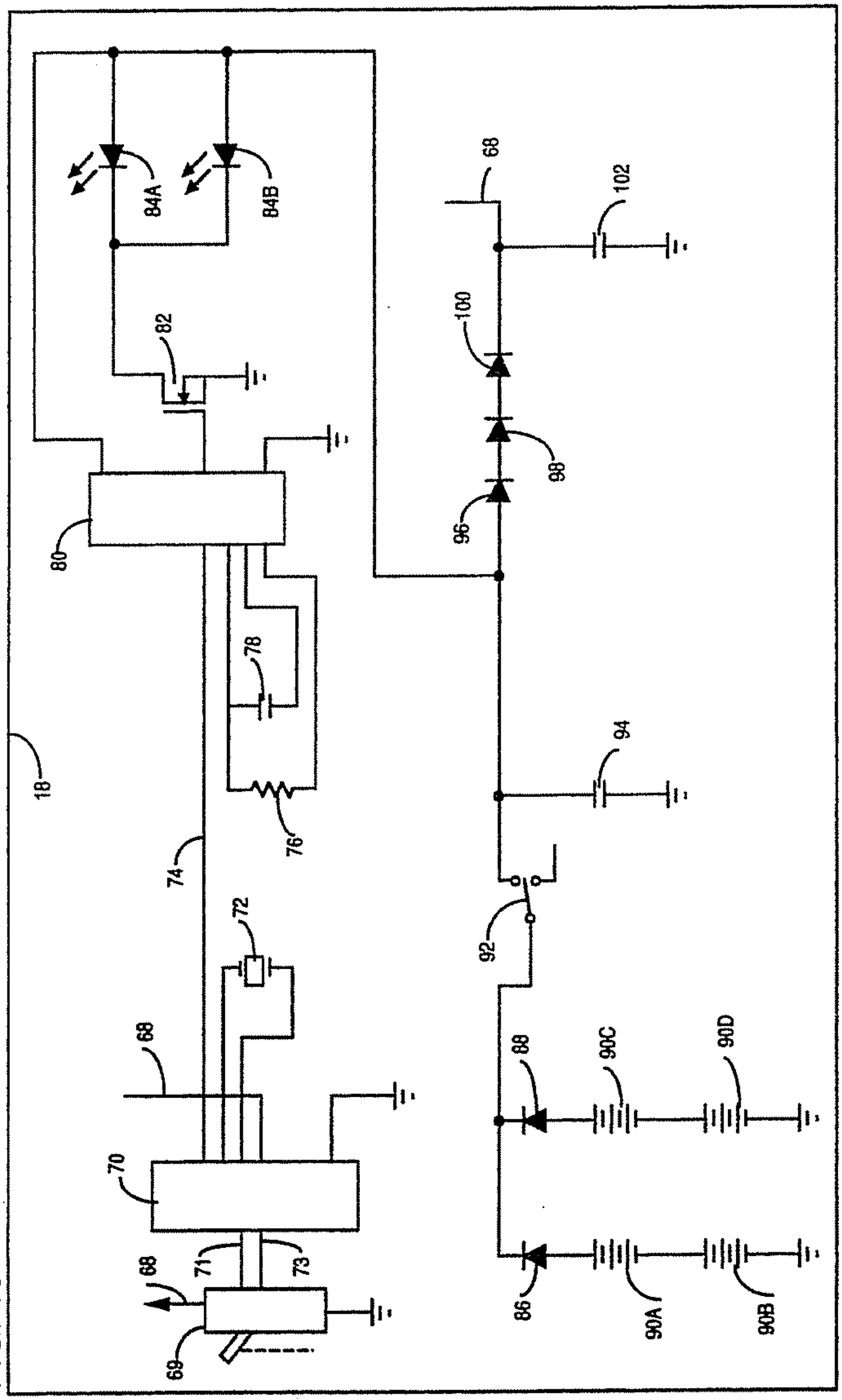

18
68
69
70
71
72
73
74
76
78
80
82
84A
84B
86
88
90A
90B
90C
90D
92
94
96
98
100
102

FIG. 13

INTELLIGENT LOCATOR SYSTEM WITH MULTIPLE BITS REPRESENTED IN EACH PULSE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates generally to an electronic locating and annunciating system for a facility and, more particularly, to a system which can continuously operate to maintain a registry of the locations in the facility of individuals and equipment; and store and generate reports of a real time record of movement from location to location of individuals and equipment in the facility.

2. Description of the Prior Art:

The need to maintain an up-to-date registry of the location of the personnel and equipment in a facility such as a building is oftentimes required to allow efficient operation. While the present invention is not so limited, an intelligent locator system is needed in a hospital setting, for example, to quickly locate operating personnel or emergency equipment at critical times. The ability to review accurate records of movement of personnel and equipment over time greatly enhances the ability of management to plan and maximize the utilization of resources, and allow a detailed study of events after an incident. One of the simplest methods for locating personnel within a facility involves a network of loudspeakers and phones or other response equipment. Such a network does not allow for locating equipment, only personnel. Also, broadcasting an announcement throughout the entire facility is distracting to all and requires an active response by the person being located. Furthermore, it is impractical with such network to maintain an up-to-date register for monitoring the location of personnel. U.S. Pat. Nos. 3,436,320; 3,696,384; and 3,739,329 disclose utilizing ultrasonic transmitters and receivers; however, there are disadvantages because the use of ultrasonics in these systems causes excess battery drain in the transmitters; and the ultrasonic signals pass through walls in a facility resulting in erroneous location indications.

Other prior art systems have been developed utilizing electro-magnetic wave energy in the infrared frequency spectrum for the transmitters and receivers. For example, German Patent No. 32 10 002 discloses a system using infrared light emitters which transmit periodic signals for detection by a receiver that in turn energizes relays to register the presence of a person carrying the infrared emitters. No suggestion is made for preventing signal overlap between two different periodic signals transmitted by emitters carried by two different individuals. Additionally, the infrared emitters operate continuously which degrades battery longevity.

Also disclosed in U.S. Pat. No. 4,275,385 is a personnel locating system which maintains a registry of individuals by tracking their entry and exit from defined areas. Each person carries a portable transmitter, and each transmitter transmits a unique twelve bit binary code word with start, stop and parity bits employing infrared light emitting diodes. Infrared receivers are positioned to allow detection of the binary code word transmitted by the transmitter. However, the receiver can only detect the transmitted code word over a limited range, and only when the receiver is positioned so as to be in the "line of sight" of the transmitter. To overcome this problem, the receivers are positioned in doorways to rooms forming the defined area. When a

person carrying a transmitter passes through the doorway, such passage is detected. The system therefore actually tracks the entrance and exit of personnel from the rooms rather than continuously maintaining the locations of the personnel. As a result, this prior art system also suffers from several inherent disadvantages. First, because a receiver only detects the transmitted signal during the brief period of time in which personnel pass through a doorway, any transmission problem occurring during this period of time results in the entry and/or exit of the personnel not be registered. Because a unique multi-bit code word as well as parity and stop/start bits must be transmitted in sequence by a portable transmitter in order to correctly identify the personnel passing through the doorway, any bit error results in an incorrect registry entry. Additionally, the number of receivers required to maintain an accurate registry of personnel increases greatly if a room contains more than one doorway allowing entrance and exit. A still further disadvantage inherent to this system occurs when two or more individuals enter through a doorway simultaneously in close proximity to one another (i.e., within the envelope of the receiver). The receiver cannot differentiate between the transmitted signals. Again, an erroneous registry indication results as no individual is registered as entering and/or exiting through the doorway. Still further, an erroneous registry indication also results when personnel pass within the envelope of the receiver, but do not pass through the doorway. For example, in a hospital setting, personnel walking along a hallway may pass within the envelope of several receivers positioned in the doorways of several rooms, but enter none of the rooms. The system would register such personnel in all of the rooms at the same time. In a hospital setting such false information is actually more detrimental than no information at all.

SUMMARY OF THE PRESENT INVENTION

According to the present invention there is provided a locating and monitoring system installable on the premises of a facility, the system including at least one transmitter means adapted for movement about the facility with a person, with an animal or with equipment to allow identification of such transmitter means at any of diverse sites in the facility, the transmitter means including means for transmitting pulse bursts at diverse times during predetermined time intervals for preventing synchronization with resident signals in the facility, the pulse bursts defining a unique binary identification code, and means responsive to the pulse bursts for establishing the location of the transmitter means in the facility.

Advantageously, a plurality of transmitters and a plurality of receivers form part of the system. The receivers each have a reception range about a premises with an allowable overlap with the reception range of another of such receivers. Each of the receivers is responsive to the pulse bursts to validate the binary identification code and thereby establish presence of the transmitter means within the reception range of a receiver. The receivers are joined to a gathering station for validating outputs from each of the receivers and forming start and stop events. The start events include the identity of the one receiver of the plurality of receivers, the binary identification code of one transmitter of the plurality of the transmitters, and when the pulse bursts of such transmitter was detected by such re-

ceiver. The stop events include the identity of the one receiver of the plurality of the receivers, the unique identification code of the one transmitter when loss of reception has occurred within the reception range, and when such loss of reception occurred. The receivers are connected to communicate as a group with a plurality of the gathering stations connected by a serial port to a central computer having a storage medium for storing the start and stop events. In the preferred form of the present invention, the system is issued for tracking the movements of hospital personnel and allied hospital equipment, and interfacing to an existing nurse call hospital system by providing: that each of the plurality of the transmitter means comprises a portable communication badge worn by allied hospital personnel, including nurses, and attached to the hospital equipment; the means for establishing the location including a receiver installed in each patient room to interface with the nurse call hospital system; a receiver installed in each patient room for indicating when the allied hospital personnel wearing one of the badges is in the room, and the class of a number of classes to which the allied hospital personnel belongs; and an interface between the central computer and the nurse call hospital system such that location queries entered at terminals of the hospital system are routed to the central computer.

According to a further aspect of the present invention there is provided a locating and monitoring system installable on the premises of a facility, the system including at least one portable transmitter means adapted for movement about the facility with a person, with an animal or with equipment to allow monitoring of such transmitter means at any of diverse sites in the facility, the transmitter means including means for generating infrared pulse bursts defining a unique binary identification code essentially including an error detection word.

In another aspect of the present invention, the system includes at least one transmitter means adapted for movement about the facility with a person, with an animal or with equipment to allow identification of such transmitter means at any of diverse sites in the facility, the transmitter means including infrared means for generating pulse bursts defining a unique binary identification code according to a pulse position scheme wherein at least two binary bits of the code are represented by one pulse.

In a still further aspect of the system of the present invention includes at least one transmitter means adapted for movement about the facility with a person, with an animal or with equipment to allow identification of such transmitter means at any of diverse sites in the facility, the transmitter means including means for transmitting pulse bursts defining a unique binary identification code, and a plurality of receiver means responsive to the pulse bursts for establishing the location of the transmitter means in the facility, and a gathering station joined to each receiver of the plurality of receivers for validating outputs from each of the plurality of receivers and forming start and stop events, the start events including the identity of the one receiver of the plurality of receivers, the binary identification code of the transmitter, and when the pulse bursts of such transmitter was first detected by such receiver; the stop event including the identity of the one receiver of the plurality of the receivers, the unique identification code of the transmitter when loss of reception has occurred within the reception range, and when such loss of reception occurred.

BRIEF DESCRIPTION OF THE DRAWINGS

Still other objections and advantages of the present invention will become apparent when the following description is read in light of the accompanying drawings in which:

FIG. 1 is a block diagram of the intelligent locator system according to one embodiment of the present invention;

FIG. 2 is a block diagram of the intelligent locator system in a hospital nurse-call system according to a preferred embodiment of the present invention.

FIG. 3 is a timing diagram showing three simultaneous infrared identification code transmissions;

FIG. 4 is one example of timing diagram of bits comprising an identification code burst;

FIG. 5 is a timing diagram showing details of a pulse position scheme according to the present invention;

FIG. 6 is a schematic illustration of the circuitry of the intelligent locator transmitter forming part of the systems of FIGS. 1 and 2;

FIG. 7 is a block diagram of the intelligent locator receiver forming part of the systems of FIGS. 1 and 2;

FIG. 8 is a schematic illustration of the circuitry for the infrared preamplifier for the intelligent locator receiver shown in FIG. 7;

FIG. 9 is a schematic illustration of the circuitry for the intelligent locator receiver forming part of the systems of FIGS. 1 and 2;

FIG. 10 is a block diagram of the intelligent locator arbitrator forming part of the systems of FIGS. 1 and 2;

FIG. 11 is a schematic illustration of the circuitry forming part of the intelligent locator arbitrator forming part of the systems of FIGS. 1 and 2;

FIG. 12 is a block diagram illustrating the intelligent locator computer forming part of the system of FIGS. 1 and 2; and

FIG. 13 is a schematic illustration similar to FIG. 6 and of a modified form of the circuitry of the intelligent location transmitter that can be used in the systems of FIGS. 1 and 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first now to the block diagram of FIG. 1, there is illustrated one form of intelligent locator system according to the present invention which is useful as a stand alone system for tracking and locating persons and equipment in a hospital; tracking and locating persons and/or product and equipment in a factory, warehouse, retail store or other space; keep records of progress of new product through the production process in a factory, and tracking animals in a storage and feeding facility.

The intelligent locator system of FIG. 1 includes a central control computer such as a Personal Computer having a 386 central processor identified for the purpose of disclosure of the present invention as an intelligent locator computer 2 because of interfacing with allied components of the system. A serial data bus 4 supplies commands between a serial port of the computer 2 at least one and up to preferably 32 local gathering stations identified as intelligent locator arbitrators 6_1, 6_2 . . . 6_{32}. The computer 2 may also include additional serial ports coupled to data bus lines 4_1, 4_2 . . . 4_n of a plurality of such intelligent locator arbitrators 6_1, 6_2 . . . 6_{32}. Communication over serial data bus lines 4_1, 4_2 . . . 4_n is based on, but not restricted to the Electronic

Industries Association standard RS-485. Each arbitrator 6_1, 6_2 . . . 6_{32} communicates by a serial data bus 8_1, 8_2 . . . 8_{32}, with up to 32 intelligent locator receivers 16_1, 16_2 . . . 16_{32}.

The intelligent locator arbitrators 6_1, 6_2 . . . 6_{32} each includes a +15 DC volt power supply 14 to supply electrical power to the associated arbitrator and line 10 to supply electrical power to intelligent locator receivers 16_1, 16_2 . . . 16_{32} coupled to the associated intelligent locator arbitrator. A ground line 12 is arranged parallel with line 10 which forms an electrical ground potential common to all of arbitrators and receivers. All the intelligent locator receivers associated with the various intelligent locator arbitrators are responsive to anyone of at least one but preferably a plurality of intelligent locator transmitter badges 18_1, 18_2, 18_3, 18_4 . . . 18_n, each of which, as will be described in greater detail hereinafter, transmits an unique bit code when chosen with 20 bits to enable up to 1,048,576 badges uniquely recognizable by the system. More than 20 code bits can be used to allow more than 1,048,876 badges to be uniquely recognized by the system. A bit code greater than 20 bits may be adopted with out departing from the spirit of the present invention.

The intelligent locator badges 18 are constructed in a manner suitable to be worn by persons, animals, and/or equipment and transmit a unique identification code using infrared transmissions. The receivers 16 with infrared detectors are installed at any of various different locations throughout a facility to allow detection of the unique code emitted by any of intelligent locator transmitters 18 within a detection range. While the invention is not so limited, these receivers 16 can be installed in walls, floors, ceilings, structural parts, and special mountings provided in the facility. The functions of intelligent locator arbitrators 6_1, 6_2 . . . 6_{32} is to process the signals to determine when an unique identification code emitted by the intelligent locator transmitter 18 starts being detected by any intelligent locator receivers 16_1, 16_2 . . . 16_{32} and when the code stops being detected. The arbitrators transmit signals corresponding to these start and stop events to the computer 2. A maximum of preferably 32 intelligent locator arbitrators 6 may be connected to a serial port of the intelligent locator computer 2 via the RS-485 serial bus 4. This gives rise to the possibility of up to 1024 intelligent locator receivers 16 per intelligent locator computer 2 serial port. The operating software of the intelligent locator computer operates to read into the computer memory the start and stop events from the intelligent locator arbitrator's 6, time stamps the events, and stores the data of the event in a relational database.

A system user will be able to input a request to the intelligent locator computer 2 terminal and/or generate a report of the present location of any person, animal, or equipment which is wearing an intelligent locator transmitter badge 18 including movement of the badge with the person, animal, or equipment over any previous time period.

Referring now to the block diagram of FIG. 2, there is illustrated, in block form the preferred embodiment of the intelligent locator system for use in a specific application of a computer controlled hospital nurse call system, preferably a Wescom System 3000™. The nurse call system includes a nurse call CPU 26 having an input device 26A such as a key board. The CPU 26 fulfills the function of a central computer controlling the nurse call system that also includes one or more nurse-call central control terminals 22_1, 22_2, . . . 22_{32} each connected to communicate over a standard RS-232 bus 24 with the nurse call CPU 26. Terminals 22_1, 22_2, . . . 22_{32} are each connected by a parallel data bus 28 to communicate with patient room stations 32 dispersed about a local area of the facility such as a floor of a hospital. The nurse call CPU 26 is coupled by an ethernet high speed serial data bus 20 using standard tcp/ip protocol with the intelligent locator computer 2. When operating with a nurse-call system, the intelligent locator system of the present invention replaces automatic or manual locators that are normally found with such a system. When nurses wearing the intelligent locator transmitter badges enter a patient's room in response to a call, the intelligent locator system automatically detects their presence and communicates that information to the nurse-call system and thereby eliminates the need for the nurses to manually register their presence. An example of the operation of the system shown in FIG. 2 is that the intelligent locator computer 2 stores information identifying the level of the person or personnel wearing all badges, e.g., RN, LPN, aid, as well as the specific identity of the nurse wearing that badge and transmits the level information back through the intelligent locator arbitrators 6_1, 6_2 . . . 6_n and through intelligent locator receiver 16_1, 16_2 . . . 16_{32} to the patient stations 32 which need that level information to determine whether the nurse being detected by the intelligent locator receiver 16 is of the requisite qualification level to respond to the need of the nurse call placed at the patient station.

The nurse-call system operators, at their own nurse-call terminals through the ethernet communication line 20 between the intelligent locator computer cpu 2 and the nurse-call cpu can request information about the current location of any nurse, other personnel or hospital equipment wearing an intelligent locator transmitter badge 18. A detailed description of the construction and operation of intelligent locator arbitrator 6, intelligent locator receiver 16 and intelligent locator transmitters 18 follows.

An important feature of the present invention is the coding for transmission and decoding of received pulse bursts at diverse times during predetermined time intervals to define an unique binary identification code for the operation of the locating and monitoring system. To facilitate an understanding of the underlying principle of the present invention, reference is now made to the diagram of FIG. 3 wherein there is illustrated timing diagrams in graphical form of three simultaneous infrared transmissions by three separate intelligent locator transmitters over a four second period. It is an important and novel feature of the present invention that a pulse burst of 20 milliseconds duration defines a unique binary identification code that is transmitted approximately once a second with its position in time relative to the start of each second determined by an algorithm. As shown in FIG. 3, for illustrative purposes only, when the code bursts 40 of all three badges happen to line up at the same time of 0 second thus interfere with one another as depicted at the far left of FIG. 3, then during the next second all three pulses and any two of the pulses will not simultaneously occur or line up in time because the pulses emitted by their respective transmitters occur in time according to a different code determined by when the pulse transmission occurred during the preceding second. In this way, multiple badges carried into the same room of a facility can be distin-

guished from one another by their infrared pulse transmissions as detected by the receiver. Moreover, the infrared transmission by only one such transmitter can be uniquely identified from all other infrared pulse transmissions whether from other badge transmitters or sources of infrared pulse transmissions occurring within the facility. In this regard it is to be noted that infrared pulse transmissions may be emitted by equipment or devices carried by persons within the facility. Thus, the present invention is intended to enable unique identification of any given badge with respect to other badges and sources of infrared transmissions. The algorithm for determining when within each second the unique identification code is transmitted by a infrared pulse burst resides in the software of a microcontroller forming part of the intelligent locator transmitter **18**. The algorithm functions by accessing through a 20 bit identification code at a rate of 1 bit per second using a current bit value of "0" or "1" to determine whether to transmit a code burst during the first half or the second half of the current second. The algorithm also functions at the same time to step through the 20 bit identification code at a rate of 4 bits at a time during each second and using a current 4 bit part of the code to determine when the pulse bursts are to be transmitted within that first or second half of a second. The time span of a second was chosen arbitrarily and may, for example, comprise a time period 1 and ½ seconds long.

As described in regard to FIG. 3, the pulse bursts occur for a duration of time selected for the purpose of describing the present invention to be 20 milliseconds. In FIG. 4 a 20 millisecond time interval is depicted during which **14** infrared pulses, each identified by reference numeral **42**, occur with an approximate 10 microsecond duration which is identified by reference numeral **44**. The 20 millisecond burst transmission is made up of 3 components. The first is a start bit interval **46** during which an initial pulse **42** occurs to synchronize the receiver **16** for reading the transmission. The second component of the pulse transmission are 10 pulses occurring during an interval **48** representing a 20 bit code. A third component of the pulse transmission, which also comprises an important novel feature of the present invention, are three pulses **42** representing a 6 bit checksum occurring during an interval **50** and detected and used by a receiver **16** to insure integrity of the received data.

Referring again to the time interval **48** of FIG. 4, this interval is depicted with greater detail in FIG. 5 wherein the graphical illustration represents a timing diagram of the pulse position scheme used to represent 2 binary data bits by the transmission of 1 infrared pulse transmission **42**. It is a further important novel feature of the present invention to provide that each infrared pulse **42** represents 2 binary bits of code which not only reduces the number of necessary infrared pulses to define the code but also offers a material saving to the life of a battery power supply for the transmitter. It is of vital importance to conserve battery power consumed by the operation of the transmitter. Battery drain occurs when the infrared emitters are turned ON for each pulse. This is a significant advance over known prior art systems which used a burst of pulses for each bit with the pulse occurrence being varied in frequency to distinguish "0" from a "1". In FIG. 5 each 10 microsecond duration **44** represents the emission of an infrared pulse **42** that occurs sometime during a 1.5 millisecond bit space **52**. The bit space is defined to provide **4** discrete time intervals within which a pulse can occur. When a pulse occurs during the first of the 4 intervals, it represents a 2 binary bit code "00" which is shown to occur during the bit space **60** as a third code pulse. When a pulse occurs during a second of the 4 intervals, it represents a 2 binary bit code "01" which is shown to occur during the bit space **56** as a first code pulse. When a pulse occurs during a third of the 4 intervals, it represents a 2 binary bit code "10" which is shown to occur during the bit space **62** as a fourth code pulse. When a pulse occurs during a fourth of the 4 intervals, it represents a 2 binary bit code "11" which is shown to occur during the bit space **58** as a second code pulse.

As noted above, only 4 intervals of a defined 6 interval bit space are used for the occurrence of a pulse. The first interval occurring before the middle 4 intervals and the sixth interval occurring after the middle 4 intervals enable the circuity of the receiver **16** to distinguish between successively occurring pulses especially where, for example a second code pulse "**58**" defines a code "11" is followed by a third code pulse **60** defining a code "00".

INTELLIGENT LOCATOR TRANSMITTER 18

In FIG. **6** schematically illustrated is the circuitry of an intelligent locator transmitter useful in the systems of FIGS. **1** and **2**. The transmitter **18** includes a microcontroller **70** comprised of an IC package containing a programmable memory for an operating program whose function is to define an unique 20 bit identification code for identifying the transmitter uniquely among all other transmitters and other sources of possible infrared pulse emissions occurring within the receiving range of the receivers **16**. A microcontroller suitable for use in the preferred embodiment of the present invention is a Microchip PIC16C54LP, which is a low voltage CMOS device. The microcontroller operates at a slow speed set externally at, for example, 32 kilohertz, by a quartz crystal **72** which is the minimum speed sufficient to generate identification code pulses and minimize power consumption which is directly related to the speed of operation. A serial bit stream of 125 microseconds wide logic pulses is output on data line **74** to a monostable multivibrator **80** formed by an IC package per se well known in the art to produce an output on line **81** in the form of 10 microsecond pulses for transmission which turns ON a MOSFET transistor **82**. Infrared light emitting diodes **84A** and **84B** are energized when transistor **82** is turned ON. Diodes **84A** and **84B**, per se well known in the art, are preferably selected to emit bursts of infrared radiation at a wave length preferably selected at 940 nanometers. Resistor **76** and capacitor **78** forms an RC circuit which determines the 10 microsecond pulse width output by multivibrator **80**. Coin-sized flat lithium cell batteries **90A**, **90B**, **90C** and **90D** supply power for the operation of the intelligent locator **18**.

Diodes **86** and **88** are arranged to form rectifiers by their connection between **90A**, **90B**, **90C** and **90D** for protecting the circuitry of the transmitter in the event the batteries are installed with their polarity reversed. The transmitter can be turned OFF by operation of switch **92** coupled in power supply line **93**. Capacitor **94** stores an electrical charge between pulse emissions which is discharged when the light emitting diodes **84A** and **84B** are turned ON for emitting high intensity emission pulses. A serial arrangement of diodes **96**, **98** and **100** establish a low voltage in line **68** for powering the

microcontroller 70. The voltage setting function of diodes 96, 98 and 100 contributes to a reduction of power consumption by reducing the operating voltage supplied to the microcontroller 70. Capacitor 102 coupled between the voltage supply line 68 and ground minimizes noise and other interference to insure reliable operation of the microcontroller 70 by forming a buffer and filter in the voltage supply line 68.

INTELLIGENT LOCATOR RECEIVER 16

In FIGS. 7, 8 and 9 schematically illustrated is the circuitry of an intelligent locator receiver which is useful in the embodiments of the systems shown in FIGS. 1 and 2. Turning first to FIG. 7, there is illustrated by the block diagram two circuit boards, one of which is a preamp board 106, and the other a logic board 108 which are mounted to a single gang face plate for installation in a wall or in a ceiling of a room within the premises of a facility where the system of the present invention operates. Preamp board 106 is mounted directly to the face plate and logic board 108 forms the back board mounted behind the preamp board in a piggy-back fashion. Preamp board 106 includes Pin photodiode 118 for detecting by impingement infrared pulses 104 emitted by an intelligent locator transmitter 18. Three light emitting diodes 120, 122 and 124 emit different colors of light to give a visual indication on the receiver face plate of three possible levels of persons such as nurses, e.g. RN, LPN and aid whose presence is detected by the system. The logic board supplies power to the preamp board for the operation thereof including illumination of the light emitting diodes 120, 122 and 124 in response to signals received in a three wire bus line 116 from the logic board. The logic board decodes pulses output from the preamp board in line 110 to validate a code and communicate a validation of the code by data transmission to intelligent locator arbitrator 6. It will be understood that the system of FIG. 2 provides that the arbitrator 6 forwards data to the receiver 16 that includes information in the form of a signal indicative of the level of the nurse detected by the intelligent locator receiver which has been recorded thereby.

FIG. 8 shows the greater details of the preamp board 106 wherein it can be seen that there is included an infrared preamplifier 126 having input terminals coupled to PIN photodiode 118 and an input terminal coupled to receive a +12 VDC power supply by line 112. A common ground potential is also presented by line 114. Infrared pulses impinging on diode 118 cause a forward biasing thereof causing a pulse input of current to the preamplifier 126 which converts the current pulse whose duration is 10 microsecond to a 12 volt logic pulse of approximately 50 to 300 microseconds in duration. The pulse width is directly proportionate to the intensity of the detected infrared light pulse and is communicated to the logic board by line 110. The diode 120 designed to emit green light is coupled through a current limiting resistor 128 to indicate by designation a nurse level presence of "1" by the occurrence of a low voltage level in line 116A received from the logic board 108. The diode 122 designed to emit yellow light is coupled through a current limiting resistor 130 to indicate by designation a nurse level presence of "2" by the occurrence of a low voltage level in line 116B received from the logic board 108. The diode 124 designed to emit red light is coupled through a current limiting resistor 132 to indicate by designation a nurse level presence of "3" by the occurrence of a low voltage level by line 116C supplied by the logic board 108.

FIG. 9 shows greater details of the logic board 108 wherein the circuitry includes a voltage protection diode 134 in the +15 VDC input 10 and a filter capacitor 136 that is parallel with a 12 voltage regulator 138 whose output is a 12 VDC power supply filtered by capacitor 140 for delivery to preamp board 106 by line 112. The preamp board 106 is coupled to ground potential by ground line 114. The +12 VDC output from voltage regulator 138 is also coupled to form an input to a voltage regulator 142 whose output is a +5 VDC filtered by capacitor 144 for powering 5 volt logic devices on the logic board that include microcontroller 158, a universal asynchronous receiver transmitter hereinafter identified as uart 156, and a RS-485 serial data transceiver 148. The +12 VDC logic pulses occurring as outputs from preamplifier 126 in line 110 are input to a voltage level conversion circuit that includes voltage level resistors 162 and 164, the latter coupled to the gate of transistor 168 which outputs through resistor 166 +5 VDC pulses to the microcontroller 158. The microcontroller 158 samples the input bursts to establish the validity of an identification code. The validation is made when the identification code consists of, as shown in FIG. 4, a start pulse 46 followed by 10 pulses 48 representing a 20 bit code, followed by three pulses 50 representing a 6 bit checksum.

For this purpose, the microcontroller 158 includes an operating program to perform an important and believed novel feature of the present invention of causing operation of the microcontroller to recalculate a checksum by using bursts from the received identification code and then comparing the freshly calculated checksum with the checksum received with the identification code. When the freshly calculated checksum equals the checksum received with the identification code, the code is established as valid. When the comparison shows an inequality of the compared checksums then the code bursts pulses transmission is ignored. In this way, if too few code burst pulses or too many code burst pulses (as in the case of overlapping pulse transmissions) are detected then those transmissions are also ignored.

When the operation of microcontroller 158 establishes the validity of a received identification code then the microcontroller outputs a signal corresponding to the validated code to the intelligent locator arbitrator $6_1, 6_2$ - - - 6_{32} by way of the RS-485 serial data bus 8. An operating clock for the microcontroller 158 is formed by a quartz crystal 160. In the system shown in FIG. 2, the arbitrators 6_1, 6_2 - - - 6_{32} return the nurse level information corresponding to that received identification code to the microcontroller 158 of the receiver. This nurse level information is then transmitted to the patient station 32 by the three lines 30A, 30B and 30C which incorporate protection diodes 150, 152 and 154. The microcontroller 158 outputs signals through base resistors 170, 174 and 178 coupled through transistors 172, 176 and 180 respectively, to lines 116A, 116B and 116C to energize the respective light emitting diodes located on the intelligent locator receiver preamp board 106. The microcontroller 158 also communicates with arbitrator 6 by the RS-485 databus 8. As can be seen from FIG. 9, microcontroller 158 responsive to an operating clock formed by quartz crystal 160 communicates through the uart 156 and the RS-485 interface integrated circuit 148 with arbitrator 6 over data lines 8A,

8B, 8C and 8D collectively forming data bus 8. The uart 156 is an integrated circuit whose function is to convert parallel data received from microcontroller 158 to serial data and output the serial data at a selected baud rate to the RS-485 interface integrated circuit 148. The uart 156 also receives serial data at a selected baud rate from the integrated circuit 148 and performs a conversion to parallel data which is read as an input to microcontroller 158. The uart 156 derives its operating clock from a quartz crystal 146. The RS-485 interface IC 148 delivers serial data output by the uart 156 to differential outputs 8A and 8B to be transmitted over a twisted wire pair. Also, the RS-485 interface IC 148 converts differential inputs in lines 8C and 8D from a twisted pair line to serial data inputs which can be read by the uart 156.

INTELLIGENT LOCATOR ARBITRATOR 6

In FIG. 10 schematically illustrated is a block diagram of the circuitry of the intelligent locator arbitrator 6 useful in the systems of FIGS. 1 and 2. The arbitrator includes a logic circuit board 182 and a +15 VDC power supply 14. Power supply 14, per se well known in the art, chosen from any one of a variety of commercially available units to deliver about 3 amps at 15 volts DC through a rectifier circuit coupled by line 184 to a standard 115 VAC line. Power supply 14 outputs +15 VDC in line 10 having a branch line 186 coupled to the logic board 182. Similarly, line 12 at ground potential also emerging from the power supply has a branch line 188 coupled to establish ground potential for the logic board 182.

Referring now to FIG. 11, the details of the circuitry forming the intelligent locator arbitrator circuit board 182 is illustrated wherein it can be seen that the +15 VDC input 186 is protected by diode 198 followed by a grounded filter capacitor 200. Beyond the capacitor 200 in the circuit is a regulator 202 whose output is at a potential of +5 VDC filtered by grounded capacitor 204 for supplying power to all of the devices that include microcontroller 222, universal asynchronous receiver transmitters 214 and 216, hereinafter referred to as uart 214 and 216, RS-485 serial data transceivers 206 and 208, signal control latches 218 and 220, the static rams 190 and 194 and the ram address latches 192 and 196.

As shown the microcontroller 222 communicates with the intelligent locator computer 2 by the RS-485 serial data bus 4 through uart 214 and the RS-485 interface integrated circuit 206. Additionally, the microcontroller 222 communicates with the intelligent locator receiver 16 by the RS-485 type serial data bus 8 through uart 216 and the RS-485 interface integrated circuit 208. The uarts 214 and 216 take the form of integrated circuits which receive parallel data from the microcontroller 222, convert the parallel data to serial data and output the serial data at a selected baud rate to the RS-485 interface integrated circuits 206 and 208. The uarts 214 and 216 also receive serial data at a selected baud rate from the RS-485 interface integrated circuits 206 and 208 and convert the serial data to parallel data read in by the microcontroller 222. Quartz crystals 210 and 212 form operating clocks for the uarts 214 and 216, respectively. The RS-485 interface integrated circuits 206 and 208 convert serial data outputs from the uarts 214 and 216, respectively, to differential outputs in lines 4A and 4B extending to the intelligent locator computer 2 with respect to IC 206 and lines 8A and 8B extending to the intelligent locator receivers 16 for transmission by way of twisted pair wire. The RS-485 interface integrated circuit 206 converts differential inputs received from twisted pair wires 4C and 4D from the intelligent locator computer to serial data inputs read by uart 214. The RS-485 interface integrated circuit 208 converts differential inputs received from twisted pair wires 8C and 8D from the intelligent locator receivers 16 to serial data inputs read by uart 216. The microcontroller 222 latches all its external control signals to the other integrated circuits on the intelligent locator arbitrators logic board 182 in two 8 bit latch integrated circuits 218 and 220. This enables the microcontroller 222 to expand its 8 bit data output port to drive 16 control signals. The microcontroller 222 also latches the address bus of the static rams 190 and 194 in two 8 bit latch integrated circuits 192 and 196. This enable the micro-controller to multiplex its 8 bit data bus with the 15 bit address bus of the static rams 190 and 194. Quartz crystal 224 forms an operating clock for the microcontroller 222.

Each arbitrator 6 is connected by an RS-485 serial bus 8 to process signals from a maximum of preferably 32 intelligent locator receivers 16. Each arbitrator 6 operates to establish the event when a transmitter 18 is first detected by a receiver 16 and the event when a transmitter 18 is no longer detected by a receiver 16 and transmits such start and stop events as signals to the intelligent locator computer 2. The microcontroller 222 in each arbitrator 6 through operation of a resident program reads the identification codes reported by each intelligent locator receiver 16 by way of RS-485 serial bus 8. If an identification code transmitter 18 has been carried into the detection range of a receiver 16, the microcontroller 222 sends a start event message containing the identification code and an identification number of that receiver 16 to the computer 2 by the RS-485 bus 4. The microcontroller 222 also stores that identification code in a static ram 190 and 194 in a table of information for that particular receiver 16. As long as the receiver 16 continues to report that identification code, the identification code remains in the static ram 190 and 194. However, when the intelligent locator stops a reporting of the identification code for more than 10 seconds, the microcontroller 222 sends a stop event message to the computer 2 and removes that identification code from the static ram 190 and 194 for that intelligent locator receiver 16. In the particular embodiment of the system shown in FIG. 2, the microcontroller 222 also receives and stores in ram 190 and 194 a table of nurse level information from the intelligent locator computer 2.

The table of nurse level information includes a list of identification codes of the badges worn by nurses and the nurse level of each such person e.g., RN, LPN or aid. When an intelligent locator receiver 16 reports an identification code which corresponds to one of the nurse codes, the microcontroller 222 sends that nurse level information to that intelligent locator receiver 16 by the associated RS-485 serial bus 8. In this way, the receiver 16 is supplied with a signal to turn ON one of the nurse level light emitting diodes 120, 122 or 124 and at the same time to deliver a signal to the patient station 32 indicating the presence of a nurse and to which of the three levels the nurse belongs.

INTELLIGENT LOCATOR COMPUTER

In FIG. 12 schematically illustrated is a block diagram of the intelligent locator computer 2 useful in the systems of FIGS. 1 and 2. The computer 2 contains an

intel 386 personal computer central processing unit 228, a monitor 226 for viewing data, a keyboard 232 for entering the data, an RS-232 to RS-485 converter box 240, a terminal for the ethernet bus 20 and a printer 242 coupled by an interface to the CPU 228. The CPU 228 also includes its own power supply which includes a line 230 for receiving 115 VAC. The PC CPU 228 controls the monitor 226 through an interface cable 234. An interface cable 238 interfaces the keyboard 232 with the CPU 228. The converter box 240 is used to convert standard RS-232 data from a serial port 236 of the CPU to the RS-485 data bus 4. Operating software in the CPU 228 receives start and stop events from the arbitrators 6, time stamps these events and stores the events in a data base. The start event includes an identifying number of the intelligent locator receiver 16, the identification code of the transmitter 18 within the range of the receiver 16 and the real time of the occurrence of the start event.

The stop event includes the identifying number of the receiver 16, the identification code of the transmitter 18 removed from the reception area of the receiver 16 and the real time of the occurrence of the stop event. The computer 2 has a front end interface to enable an operator to request the location of that person or object wearing a transmitter 18. In the embodiment of FIG. 2, CPU 228 has an ethernet interface for interfacing with the nurse call CPU 26. The ethernet interface can also be used to attach a terminal server to allow the capability of multiple terminals for use throughout the facility where operators can request location information about any transmitter 18. The CPU is equipped with necessary means including software for generating reports detailing previous movement of any transmitter over a period of time which can be generated and viewed at the terminal or reduced to hard copy by the printer 242.

In FIG. 13 schematically illustrated is another embodiment of the transmitter 18 wherein like reference numerals identify the same parts identified and described hereinbefore in regard to FIG. 6. In FIG. 13, a four position logic switch 69 is included which is connected to inputs 71 and 73 of microcontroller 70 and sets a two bit code on inputs 71 and 73 of microcontroller 70. The operating program of the microcontroller 70 reads this two bit code on its inputs 71 and 73, and incorporates that two bit code in its 20-bit identification code for transmission. This additional two bit code forms data, which is changeable in the field via the switch 69, is useful in the system of FIG. 2 to differentiate the three levels of nurse (RN, LPN, aid) from other identification badges. In this embodiment, the receivers 16 determine nurse level information directly from the received pulse bursts and pass that information to the patient station 32 without have to wait for the arbitrator 6 to look up that level information in a table and communicate that information back to the receiver 16.

While the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims.

We claim:

1. A locating and monitoring system installable on the premises of a facility, said system including:

a plurality of transmitter means adapted for movement about said facility with a person, with an animal or with equipment to allow identification of such transmitter means at any of diverse sites in the facility, each of said transmitter means including means for transmitting infrared pulse bursts, each of said infrared pulse bursts defining a unique binary identification code comprising a plurality of binary bits of sufficient number that each of said transmitter means in said facility transmits a different binary identification code, means responsive to an algorithm for controlling said means for transmitting said infrared pulse bursts during a predetermined time interval, with the occurrence of each pulse burst in time relative to the start of each time interval varying from time interval to time interval, the amount of said varying being controlled by said means responsive to an algorithm incorporated in each transmitter using said unique binary identification code of that transmitter for preventing synchronization with other transmitters and with ambient periodic resident signals in the facility, and wherein said transmitter means transmits said pulse bursts, each pulse of said burst representing at least two binary bits in a pulse position scheme of the identification code data for reducing the number of pulses required to represent said unique binary identification code and therefore minimize power consumption by said transmitter means;

receiver means responsive to said pulse bursts by said plurality of transmitter means at each of said diverse sites in said facility for detecting infrared pulse bursts by said transmitter means; and

central means responsive to said receiver means for establishing the location of said transmitter means in said facility.

2. The system of claim 1 wherein said pulse bursts include an error detection code to insure integrity of pulse bursts transmission using a pulse position scheme to represent at least two binary bits with one pulse, and wherein said means responsive to said pulse bursts includes means for recalculating an error detection code using the received binary identification code and comparing the recalculated error detection code to the received error detection code for validation of the binary identification code.

3. The system of claim 2 wherein said error detection code includes a binary checksum which comprises the binary sum of all of the digits of the said binary identification code.

4. A portable communication unit comprising a portable infrared transmitter means including a portable power supply adapted for movement about the premises of a facility with a person, with an animal or with equipment to allow identification of such transmitter means at any of diverse sites in the facility, said portable infrared transmitter means including infrared emitter means controlled by controller means responsive to an algorithm unique to and with that transmitter means for producing infrared pulse bursts at diverse times during predetermined time intervals, said pulse bursts defining a unique binary identification code according to a pulse position scheme to represent at least two binary bits of the identification code data with each pulse of a plurality of pulses for reducing the number of pulses required to represent said unique binary identification code and

thereby reduce consumption of power of said portable power supply.

5. The portable communication unit of claim 4 wherein said pulse bursts include an error detection code to insure integrity of transmissions of said pulse bursts.

6. The portable communication unit of claim 5 wherein said error detection code includes a binary checksum which comprises the binary sum of all of the digits of the said binary identification code.

7. The portable communication unit of claim 4 wherein said means for transmitting pulse bursts includes a microcontroller having memory containing said unique binary identification code.

8. The portable communication unit of claim 7 wherein said microcontroller includes microcode to calculate a checksum of said binary identification code and generates said pulse bursts which include a start bit, said binary identification code, and said checksum.

9. The portable communication unit of claim 4 wherein said identification code comprises at least 20 binary bits to provide at least 1,048,576 different identification codes.

10. The portable communication unit of claim 4 wherein each pulse burst is of about 20 milliseconds in duration.

11. The portable communication unit of claim 4 wherein said pulse bursts each occur once in the predetermined time interval of about one second.

12. The portable communication unit of claim 4 wherein each pulse of said pulse bursts is transmitted by a 10 microsecond flash of infrared light.

13. The system of claim 4 for tracking the movements of hospital personnel and allied hospital equipment, and interfacing to an existing nurse call hospital system by providing: that each of said plurality of said transmitter means comprises a portable communication badge worn by allied hospital personnel, including nurses, and attached to said hospital equipment; said means for establishing the location including a receiver installed in each patient room to interface with said nurse call hospital system; a receiver installed in each patient room for indicating when said allied hospital personnel wearing one of the said badges enters the room, and the class of a number of classes to which the allied hospital personnel belongs; and an interface between said central computer and said nurse call hospital system such that location queries entered at terminals of said hospital system are routed to said central computer.

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